Products & Practical Information **Vol.2.1**

Dental Adhesive Resin Cement

Super-Bond C&B

●Basics and Clinical Applications●

SUN MEDICAL


Super-Bond

CONTENTS

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The clinical photographs in this brochure were provided by Dr. Kenji Ichimura, Dr. Nobuo Masaka, Dr. Masakuni Mogi, Dr. Mitsuo Nakamura, Dr. Takuji Okazaki, Dr. Hideto Takahashi, and Dr. Noboru Yasuda.

Super-Bond C&B is a self-curing dental adhesive resin cement based on acrylic resin technology. Super-Bond C&B employs "4-META" (4-methacryloxyethyl trimellitate anhyderide) as a diffusion promoter and "TBB" (tri-*n*-butylborane) as a polymerization initiator. In research publications the Super-Bond system is often referred to as "4-META/MMA-TBB Resin".

"Orthomite Super-Bond" was originally introduced in Japan as an orthodontic bonding system in 1982. Super-Bond C&B was introduced in the following year (1983) for general dental adhesive use. The difference in the kits was that Super-Bond C&B included two additional components - a "Green Activator" for the treatment of dentin and an "Opaque Ivory" Polymer powder.

Super-Bond can be used in either a bulk-mix technique or a brush-dip technique.

Though the external packaging and containers have changed over the years, there have been only minor modifications to the adhesive itself. The basic composition of Super-Bond C&B is the same as when it was first marketed.

The 4-META/MMA-TBB adhesive system is now widely recognized by dentists around the world for its high bond strength and reliability.

Dental Adhesive Resin Cement

Super-Bond C&B

● Contents of the kit

Monomer	10mL
Catalyst S	0.7mL
Polymer (L-Type Clear)	3g
Polymer (L-Type Radiopaque)	5g
Red Activator	5mL
Green Activator	5mL
Dispensing Dish	1
Sponge(L・S)	1
Measuring Spoon (Standard)	1
Measuring Spoon (Small)	1
Brush Handle (Straight)	1
Brush Handle (Bent)	1
Brush Tips (Blue) 〈for Bulk-mix〉	10×2
Brush Tips (White・L) 〈for Brush-dip〉	10
Brush Tips (White・S) 〈for Brush-dip〉	10

Adhesive Luting Cement

C&B-METABOND

In the United States, Super-Bond C&B is marketed as "C&B-Metabond" by Parkell. The basic components of C&B-Metabond are similar to those of Super-Bond C&B.

■ Available Components and Accessories

● Polymer


Clear 3g
(sold separately)


Esthetic 3g
(sold separately)


Opaque Ivory 3g
(sold separately)


Opaque Pink 3g
(sold separately)


L-Type Clear 3g


L-Type Esthetic 3g
(sold separately)


L-Type Radiopaque 5g

● Measuring Spoon

Standard

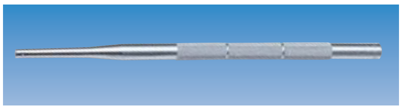
Small

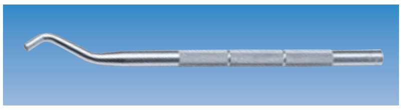
Large
(sold separately)

Relative volumes 1 corresponds to 0.2mL

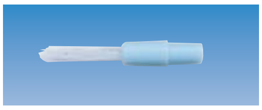
Measuring Spoon	Small cup	Large cup
Small	0.75	1.5
Standard	1	2
Large	1.2	2.4

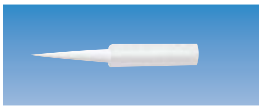
● Brush handles

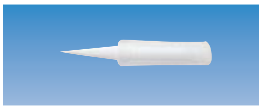

Straight


Bent

● Brush Tips


Blue (for Bulk-mix)


White・L (for Brush-dip)


White・S (for Brush-dip)

Adhesive Primer for Precious Metal

V-PRIMER

V-PRIMER is a one-component primer for bonding to precious metals (including Au/Ag/Pd alloys). It is based on the adhesive monomer called "VTD"*-a derivative of triazine-dithiol. Simple coat on precious alloy with V-PRIMER prior to application of Super-Bond C&B improves the durability of the bond. V-PRIMER eliminates the need for other bond-enhancing steps, such as heat treatment or tin plating.

*6-(4-vinyl benzyl-*n*-propyl)amino-1,3,5 -triazine-2,4-dithiol

MTL-V PRIMER

In the United States, V-PRIMER is available as "MTL-V PRIMER", marketed by Parkell.

Adhesive Primer for Porcelain Bonding

Porcelain Liner M

Porcelain Liner M is a primer for bonding to unetched porcelain. Its formula includes a silane coupling agent.
Porcelain Liner M significantly improves both the bond strength and the durability of Super-Bond C&B to ceramic surfaces.

Etch-Free

In the United States, Pocelain Liner M is available as "Etch-Free", marketed by Parkell.

2. Characteristics of Super-Bond C&B

2.1 Components of the Super-Bond C&B system

The components and main ingredients of Super-Bond C&B are shown in Table 2-1.
The mixture of the Monomer, Polymer and the Catalyst S polymerizes to create a tenacious dental adhesive resin.
The main ingredient of the Monomer is MMA (methyl-methacrylate). The main ingredient of the Polymer is PMMA (polymethyl-methacrylate), which is polymerized MMA. These are the same components as in acrylic self-curing resin ... arguably the most widely used dental material in the world.
4-META is added to the Monomer in order to promote diffusion. The 4-META (a derivative of MMA) polymerizes with the MMA to form a "co-polymer".
TBB, the main ingredient of the Catalyst S, is an initiator for polymerization. The 4-META monomer and the TBB catalyst are what make the Super-Bond C&B system behave so differently from other self-curing resins.
The "Red Activator", the "Green Activator", the "V-PRIMER" and the "Porcelain Liner M" are conditioners that improve adhesion to (respectively) enamel, dentin, precious metal, and porcelain.

Table 2-1 Components and major constituents

Components		Major constituents	In the kit
Catalyst S		TBB, acetone	Yes
Monomer		MMA, 4-META	Yes
Polymer	Clear	PMMA	Optional
	Esthetic	PMMA, pigments	Optional
	Opaque Ivory	PMMA, pigments	Optional
	Opaque Pink	PMMA, pigments	Optional
	L-Type Clear	PMMA	Yes
	L-Type Esthetic	PMMA, pigments	Optional
	L-Type Radiopaque	PMMA, radiopaque pigments	Yes
Red Activator		Phosphoric acid	Yes
Green Activator		Citric acid, $FeCl_3$	Yes

Related products	Major constituents	In the kit
V-PRIMER	VTD, acetone	Optional
Porcelain Liner M	Silane coupling agent, 4-META	Optional

2.2 Physical properties of polymerized Super-Bond C&B

Super-Bond C&B is classified as an "adhesive resin cement". Resin cements contain components different from conventional inorganic cements. They require different clinical handling and their mechanical properties are very different from those of inorganic cements.
Most adhesive resin cements consist of polyfunctional dimethacrylate-based monomers, such as Bis-GMA, and inorganic fillers of fine glass and silica. In other words, their composition is similar to that of resin composites.
After curing, these composite resin cements form three-dimensional networks of polymerized bi-functional monomers combined with inorganic fillers with high mechanical properties. They create a rigid structure with high values in such mechanical properties as micro-hardness and compressive, tensile and flexural strength.
Super-Bond is different. When it cures, it consists of linear polymers of MMA without inorganic fillers (except, of course, for the small pigment traces necessary for shading and for the radio-opacifier in the Radiopaque powder.) The resin structure has a micro-hardness and flexural modulus substantially lower than those of composite resin cements.
These unique mechanical properties are one secret to Super-Bond C&B's extraordinary performance. Ref. 2-1
For example, in one study Ref. 2-1, researchers reported they were unable to measure Super-Bond's compressive and tensile strengths. Because of its low

Ref. 2-1

(Yoshida K, Funaki K, Tanagawa M, Matsumura H, Tanaka T and Atsuta M: Properties of Commercially Available Luting Agents, Journal of Japan Prosthodont Society, 39(1), 35-40, 1995)

Mechanical properties of luting cement

Cement	Knoop hardness number (KHN)	Compressive strength (MPa)	Diametric tensile strength (MPa)	Flexural strength (MPa)
EC (Zinc phosphate cement)	49.2	124.8	4.4	10.6
HC (Carboxylate cement)	17.3	53.2	5.1	12.4
FB (Glass ionomer cement)	38.4	163.1	10.4	5.5
BR (Resin Cement)	49.8	233.9	34.8	86.5
ID (Resin Cement)	50.0	206.8	45.4	90.0
PE (Resin Cement)	49.6	192.4	32.9	89.6
PT (Resin Cement)	48.9	234.8	34.5	94.4
Super-Bond C&B	8.9	—	—	58.3

—: unable to measure

Ref. 2-2

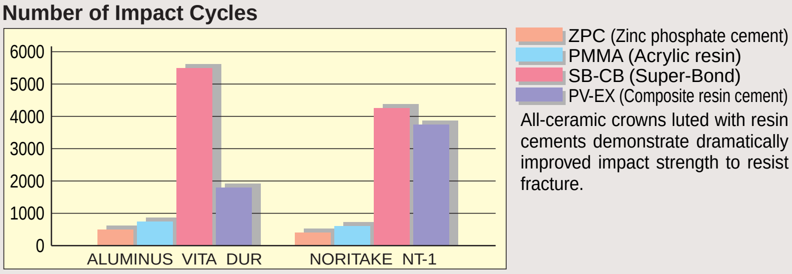
(Masuhara A et al.: Full ceramic crown; reinforcing effect of adhesion between crown and core, QDT reprint: research of present dental fine ceramic, 61-64, 1986)

①Specimens were attached to a testing apparatus and subjected to cyclical impact forces. The incisal of the ceramic crown was repeatedly struck by a hammer.

②The ceramic crowns luted with zinc phosphate cement fractured easily.

③All specimens luted with conventional cements fractured after several hundred cycles. In contrast, all specimens luted with resin cements survived even after several thousand impact loads.

Number of Impact Cycles



All-ceramic crowns luted with resin cements demonstrate dramatically improved impact strength to resist fracture.

modulus of elasticity, the Super-Bond samples showed no clear yield-point. Rather than break when they were loaded, they displayed high plastic deformation and simply changed shape.

This resilience gives Super-Bond a significant advantage over traditional adhesive cements. Because the cement remains slightly flexible after curing, it creates a more tenacious bond with higher resistance to occlusal impact stresses. Ref. 2-2

In clinical cases, the cement is very versatile. For example, it allows splinting of loose teeth and "instant bonded bridges" using a resin denture tooth (or even the crown of an extracted tooth) as the pontic. (See the clinical cases 1-8, 2-1, 2-2, 2-3, 2-4)

Ref. 2-3 shows the water sorption and solubility of both conventional cements and resin cements. As you can see, Super-Bond's water sorption and solubility are similar to other resin cements and significantly lower than conventional inorganic cements.

You can see the clinical results of this low sorption/solubility in Ref. 2-4. After 11 years in the oral cavity, Super-Bond C&B showed some physical wear at the margins, but only the slightest trace of discoloration and degradation.

Ref. 2-3

(Yoshida K, Funaki K, Tanagawa M, Matsumura H, Tanaka T and Atsuta M: Properties of Commercially Available Luting Agents, Journal of Japan Prosthodont Society, 39(1), 35-40, 1995)

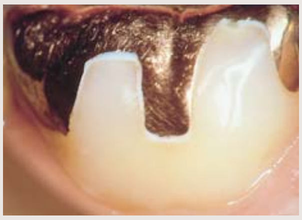
Water sorption and solubility of various luting cements

Cement	Water sorption* (μg/mm³)	Solubility** (μg/mm³)
EC (Zinc phosphate cement)	149.3	41.3
HC (Carboxylate cement)	309.3	33.8
FB (Glass ionomer cement)	211.6	34.4
BR (Resin Cement)	24.2	14.2
ID (Resin Cement)	31.5	9.5
PE (Resin Cement)	18.2	3.8
PT (Resin Cement)	32.2	17.8
Super-Bond C&B	31.2	12.1

* JIS T6514 standard
** Solubility in water JIS T6514 standard

Ref. 2-4

(Edited by research group of clinical adhesion: Clinic of adhesion, p7, 1996)



Twenty-two months after re-cementation (September 1984). Notice the exposed resin layer (250 micron) due to poor marginal fit.

Eleven years and 1 month after re-cementation (December 1993). Though wear of the exposed cement is evident, there is no recurrent caries or discoloration.

2.3 Diffusion promoter "4-META"

The monomer liquid of Super-Bond C&B contains 4-META (4-Methacryloxyethyl trimellitate anhydride). This component promotes the diffusion of monomers into tooth structure to form a hybrid layer (also called a "resin-impregnated layer").

The 4-META monomer was invented through the extensive research by Emeritus Professor Eiichi Masuhara (Director of the General Dental Research Center) and Professor Nobuo Nakabayashi from Institute for Medical and Dental Engineering, Tokyo Medical and Dental University.

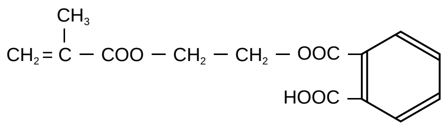
Diffusion promoting monomers contain hydrophilic and hydrophobic groups within the molecule. Fig. 2-1 shows the representative molecular structures of various diffusion promoting monomers. These monomers co-polymerize with MMA monomers.

4-META, the diffusion promoter in Super-Bond C&B, was first reported in 1978. It was shown to adhere to dental alloys as well as to teeth.

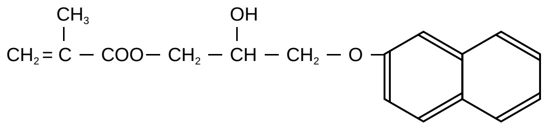
(Takeyama M et al.: Studies on Dental Self-Curing Resin (17) Adhesion of PMMA with Bovine Enamel or Dental Alloys, Journal of the Japan Society for Dental Apparatus and Materials, 19(47), 179-184, 1978)

Fig. 2-1 Diffusion promoting monomers

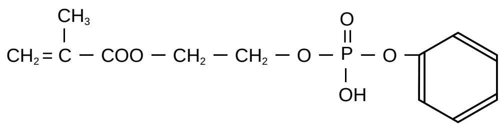
1) Methacryloxyethyl phthalate 〈1967〉



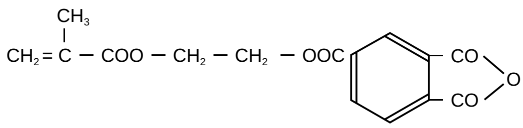
2) Hydroxy naphthoxypropyl methacrylate (HNPM) 〈1975〉



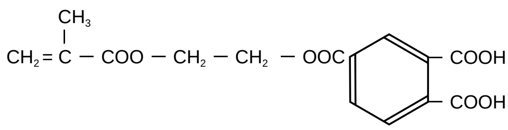
3) Methacryloxyethyl phenyl phosphate (Phenyl-P) 〈1978〉



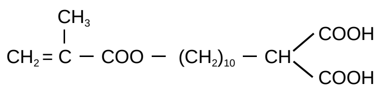
4) 4-methacryloxyethyl trimellitate anhydride (4-META) 〈1978〉



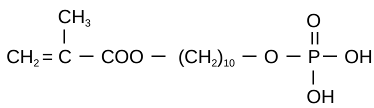
5) 4-methacryloxyethyl trimellitic acid (4-MET)



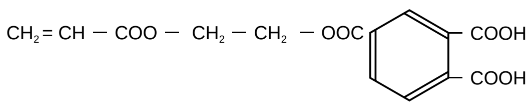
6) 11-methacryloxy - 1,1 - undecane dicarbonic acid (MAC-10)



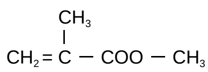
7) 10-methacryloxydecamethylene phosphoric acid (MDP)



8) 4-acryloxyethyl trimellitic acid (4-AET)



(Reference) Methyl methacrylate (MMA)



2.4 Polymerization initiator "TBB"

TBB is Super-Bond C&B's polymerization initiator. It is created by partial pre-oxidation of Tri-*n*-butyl borane.

In 1958, Prof. Eiich Masuhara, Assistant Prof. Kuniharu Kojima and others first used TBB as a polymerization initiator for methyl methacrylate (MMA). It was found that the system bonded well to ivory, especially to wet ivory.

Our general understanding of the reaction mechanism is as follows:

Because TBB's reactivity is extremely high, oxygen reacts with the boron atom to form peroxide. This triggers the reaction chain. At first a butoxy radical is generated which forms a butyl radical to initiate polymerization of the MMA. Fig. 2-2

(Sato T, Hibino K, Otu T: Journal of the Japan Chemical Society, 1080, 1975)

Despite its effectiveness as an initiator, pure Tri-*n*-butyl borane has one major disadvantage. It is so reactive that it begins smoking and burning the instant it is exposed to oxygen. In Super-Bond's Catalyst S, the excessive reactivity of pure Tri-*n*-butyl borane is reduced through partial pre-oxidation. Pre-oxidation changes one of the butyl-groups into a butoxy-group to form butoxybutyl borane. This modified TBB is as effective as pure TBB in initiating the setting reaction, but without the extraordinary flammability of pure TBB.

(Nakabayashi N et al.: Development of Adhesive Pit and Fissure Sealants Using a MMA Resin Initiated by a Tri-*n*-butyl borane Derivative, J. Biomed. Mater. 12, 149-165, 1978)

TBB (the main component of the catalyst) is believed to promote radical formation in the presence of oxygen and water. As a result Super-Bond C&B forms stable adhesion in clinical situations where creating a completely dry environment is virtually impossible.

(Okamoto Y, Takahata K, Saeki K: Studies of the Behavior of Partially Oxidized Tributylborane as a Radical Initiator for Methyl Methacrylate (MMA) Polymerization, Chemistry Letters, The Chemical Society of Japan, 1247-1248, 1998)

Fig. 2-2 Radical generation through reaction of TBB with oxygen

$$R_3B + O_2 \rightarrow R_2BO_2\cdot + R\cdot$$
$$R\cdot + O_2 \rightarrow RO_2\cdot$$
$$RO_2\cdot + R_3B \rightarrow RO_2BR_2 + R\cdot$$
$$MMA + R\cdot \rightarrow (MMA)_nR$$

(R=*n*-Butyl)

Q&A 1

Q: Does Catalyst S pose a fire hazard? What procedures should be followed if the catalyst is accidentally spilled?

A: If the Catalyst S is accidentally spilled on a non-absorbent surface (a table, for example), it will not start smoking or burning.
However, if the Catalyst soaks into a porous flammable material (such as dry tissue paper or cotton gauze), it could start smoldering. Handle the Catalyst syringe carefully. (Do not break the syringe.)
Spilled catalyst should be wiped up with wet gauze (or something similar) and then rinsed in water.
If Catalyst S enters the eye, immediately rinse with copious amounts of water. The patient should be examined by an ophthalmologist.

Q&A 2

Q: How should we store "Catalyst S"? Should the syringe be refrigerated?

A: If Catalyst S is exposed to air, it reacts with the oxygen and moisture (See Fig. 2-2) and gradually loses strength.
To prevent leakage, after each use unscrew the syringe's screw-plunger two turns (counter-clockwise). This will relieve the pressure within the syringe. Then replace the cap. Store the catalyst at room temperature in a location where there will be minimal temperature fluctuation. Avoid high humidity and direct exposure to sunlight.
Do not refrigerate. If you place the catalyst in the refrigerator, the liquid will contract as it chills. This creates a slight vacuum within the syringe, that will suck in air and cause TBB degradation.
An expiry date is printed on the syringe. The catalyst should be used by that date.

2.5 Polymerization of Super-Bond C&B

There are two ways to mix Super-Bond C&B: The brush-dip (or Neelon) technique and the bulk-mix technique.

In both techniques, the liquid components (the Calalyst S and Monomer liquid) are first mixed to create what we call the "activated liquid". Polymer powder is then added to this activated liquid in order to accelerate polymerization and allow complete curing.

Fig. 2-3

When using the bulk-mix technique, Super-Bond C&B first forms a low viscosity slurry immediately after the powder is added.

This changes with time to a sol state as the Polymer powder gradually dissolves in the activated liquid and polymerization progresses. The mix then enters a threading stage, followed by a rubbery stage. (The brush-dip technique, which produces a higher powder/liquid ratio, shows a high viscosity stage immediately after mixing). (See Fig. 5-1, 5-2)

The curing characteristics of Super-Bond C&B are similar to those of acrylic resins, but different from conventional inorganic cements. It is important to understand these curing characteristics.

Fig. 2-3 Bonding Procedure for Super-Bond C&B

Treatment of surface to be bonded

Treatment of tooth surface
Red Activator
Green Activator

Treatment of porcelain surface
Porcelain Liner M

Treatment of metal surface
Treatment of precious metal (gold/silver/palladium alloy and gold alloy)
sandblasting + V-PRIMER
Treatment of nonprecious metal alloy (Ni-Co, Co-Cr, silver and Ti alloys, stainless steel)
sandblasting

↓

Preparation of activated liquid

4 drops of Monomer, 1 drop of Catalyst S

↓

Mixing Polymer powder with the activated liquid

Bulk-mix technique
Brush-dip technique
types of polymer
Clear, Esthetic, Opaque Ivory, Opaque Pink, L-Type Clear, L-Type Esthetic and L-Type Radiopaque

↓

Luting

3. Bonding mechanisms of Super-Bond C&B

Though Super-Bond C&B shows high bond strength to dentin, enamel, metal and porcelain, the bonding mechanisms are different for each material. To assure the best possible bond, different surface treatments and procedures should be followed for each substrate. The following articles discuss the bonding mechanisms.

3.1 Bonding to dentin

Super-Bond C&B demonstrates high bond strength to dentin. Table 3-1 During almost 2 decades of use, it has earned a formidable reputation for creating stable bonds and excellent marginal seal to vital dentin, which of course, is virtually impossible to dry.

It has been suggested that the high dentin bond strength is related to the formation of a "hybrid layer" superior to those of other adhesive systems.

The "Green Activator" (an aqueous solution of 10% citric acid and 3% ferric chloride), removes the smear layer from the prepared dentin and removes the hydroxyapatite from the surface dentin. Super-Bond's Green Activator creates substantially less decalcification than phosphoric acid. The ferric chloride in the Green Activator minimizes degradation of the collagen in the zone of decalcification. As a result the Monomer can easily penetrate into the decalcified zone. Fig. 3-1

Its 4-META component dramatically enhances penetration, so the Super-Bond C&B easily penetrates into the decalcified dentin.

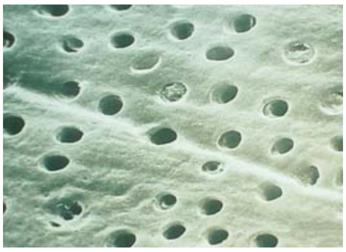
Water and oxygen prevent polymerization of most resin systems, and both oxygen and water are inherent constituents of vital dentin. Super-Bond's unique TBB catalyst initiates polymerization in the presence of oxygen and water. This means that once the monomers penetrate the decalcified zone, they begin curing at the damp, oxygen-rich tooth surface.

Super-Bond C&B's high bond strength to dentin is due to the formation of a dense "resin infiltrated dentin layer" (also known as a "hybrid layer") at the interface of resin and dentin.

Table 3-1 Bond strength to tooth

	Tooth surface treatment	Tensile bond strength (MPa)
Enamel	Red Activator	15
	Green Activator	13
Dentin	Green Activator	17

Fig. 3-1 Dentin surface treated with the Green Activator



Q&A 3

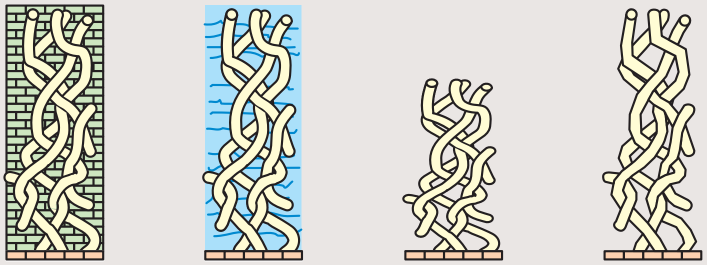
Q: What is the difference between Super-Bond C&B and adhesive systems that prepare dentin using phosphoric acid followed by wet-bonding or priming?

A: When phosphoric acid is placed on cut dentin, it removes substantial hydroxyapatite, and therefore creates a deep decalcified zone of collagen-rich dentin. If the treated surface is then dried, the unsupported collagen collapses ... the layer shrinks ... and the zone becomes much denser. As a result the monomer cannot easily penetrate through the dense organic material.
In the wet bonding technique, this decalcified dentin is kept saturated. The water prevents the collagen from collapsing. Once it has collapsed, the decalcified dentin can be restored by treatment with a primer to accelerate infiltration of the monomer. Ref. 3-1
The quality of Super-Bond's hybrid layer is promoted both by the system's Green Activator and its unique monomer.

Ref. 3-1

(Pashley DH et al.: The Effects of Dentin Bonding Procedures on the Dentin/Pulp Complex, Proceedings of the International Conference on Dentin/Pulp Complex1995, 193-201, 1995)

Changes in the Dentin Matrix During The Bonding Procedure



①Mineralized dentin matrix ②Demineralized dentin matrix filled with water (plasticized) ③Collapsed demineralized dentin matrix in air. ④Demineralized dentin matrix stiffened by organic solvents in air.

(Changes of the matrix when dentin is decalcified with phosphoric acid)

Q&A 4

Q: One manufacturer recommends that the dentin be treated with sodium hypochlorite gel (AD-gel, Kuraray Co.) after decalcification with phosphoric acid. Do you recommend treatment with this AD gel when the dentin is prepared with the Green Activator?

A: When using Super-Bond C&B, do NOT use AD gel. Even a brief application of this gel after treatment with the Green Activator will dramatically reduce the bond strength.
A weak solution of sodium hypochlorite is sometimes used to dissolved organic material, to decontaminate surfaces, or to staunch bleeding. Sodium hypochlorite is not recommended for these uses when you are bonding with Super-Bond C&B. However, if application of sodium hypochlorite is essential, apply it before treatment with the Green Activator, and limit application time to no more than 30 seconds.
Do NOT use AD gel for any of these applications, because it will compromise bond strength. If you must use a sodium hypochlorite solution prior to bonding, use it before (not after) treatment with the Green Activator. See the table.

The effect on bond strength of treatment time with sodium hypochlorite

Time of treatment (seconds)	Tensile bond strength of Super-Bond C&B (MPa)	
	AD gel	10%sodium hypochlorite
0	17	17
15	5	16
30	2*	13
60	—	6

Method
Following sodium hypochlorite treatment, bovine dentin surfaces were treated with the Green Activator. The dentin was then bonded to an acrylic rod. After immersion in water at 37°C for 24 hours, tensile bond strength was measured.
*some samples dislodged.

3. Bonding mechanisms of Super-Bond C&B

The "hybrid layer" serves a number of functions.

It protects the dentin almost like synthetic enamel. The resin-reinforced zone resists decalcification from acids, such as hydrochloric acid, and dissolution in sodium hypochlorite. It provides a barrier to both microorganisms and their byproducts, so it prevents pulpal irritation.

(Nakabayashi N: AD, 13(1), 8-13, 1995)

The dentin "hybrid layer" created when Super-Bond C&B is applied to decalcified dentin was first reported in 1982 by Prof. Nobuo Nakabayashi at Tokyo Medical and Dental University. The hybrid layer is an artificial material, a "functional dental material which can be produced by dentists in the oral environment". Ref. 3-2

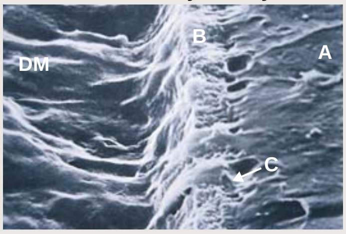
Research has shown that Super-Bond C&B's hybrid layer forms not only in vitro (in extracted teeth), but also clinically in vital human teeth. Ref. 3-3

Super-Bond C&B is extremely effective in preventing post-operative sensitivity. It creates resin tags in patent dentinal tubules to stop painful fluid movement. The hybrid layer also forms in the peritubular dentin to lock the tags in place and block leakage. Ref. 3-4

Ref. 3-2

(Nakabayashi N: Resin impregnated layer formed within the dentin side of an adhesive interface. (1), 78-81, 1982)

Formation of the hybrid layer

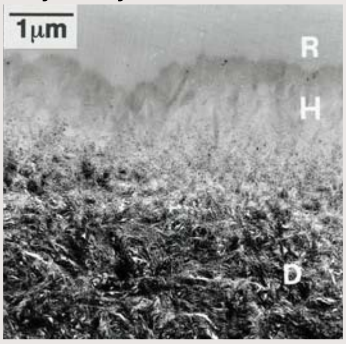


SEM image of the hybrid layer (B) formed between the Super-Bond C&B (A) and dentin (DM). Dentin was bonded with Super-Bond C&B after treatment with the Green Activator.
The specimen was cut perpendicular to the interface. Although (DM) dissolved in hydrochloric acid, the hybrid layer (B) resisted degradation. The surface of resin tags (C), like Super-Bond itself (A), was not affected by the hydrochloric acid. This suggested that the tags were resin.

Ref. 3-3

(Nakabayashi N et al.: Identification of a resin-dentin hybrid layer in vital human dentin created in vivo: durable bonding to vital dentin, Quint. Int. 23(2), 135-141, 1992)

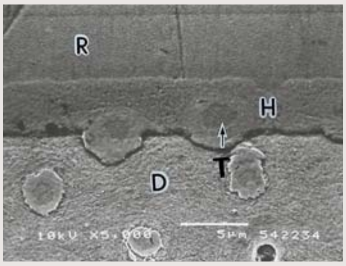
A hybrid layer formed in vivo in vital human dentin



The hybrid layer that forms where the resin penetrates vital dentin creates a resin-reinforced zone between 1 and 5 microns thick. This hybrid layer functions as a barrier against external stimuli. Large molecules cannot pass through the hybrid layer, so it prevents microbes and their byproducts from reaching the pulp.

Ref. 3-4

(Nakabayashi N et al.: Intra-oral bonding of 4-META/MMA-TBB resin to human dentin, Am J Dent, 8(1), 37-42, 1995)



A hybrid layer (H) formed in vital human dentin (D) Notice that the resin tag (T) is surrounded by the hybrid layer (H). Though resisted by pulpal fluid pressure, Monomer has diffused into the dentinal tubules to form resin tags. Monomer has also diffused into the peritubular dentin and hybridized.

3.2 Bonding to enamel

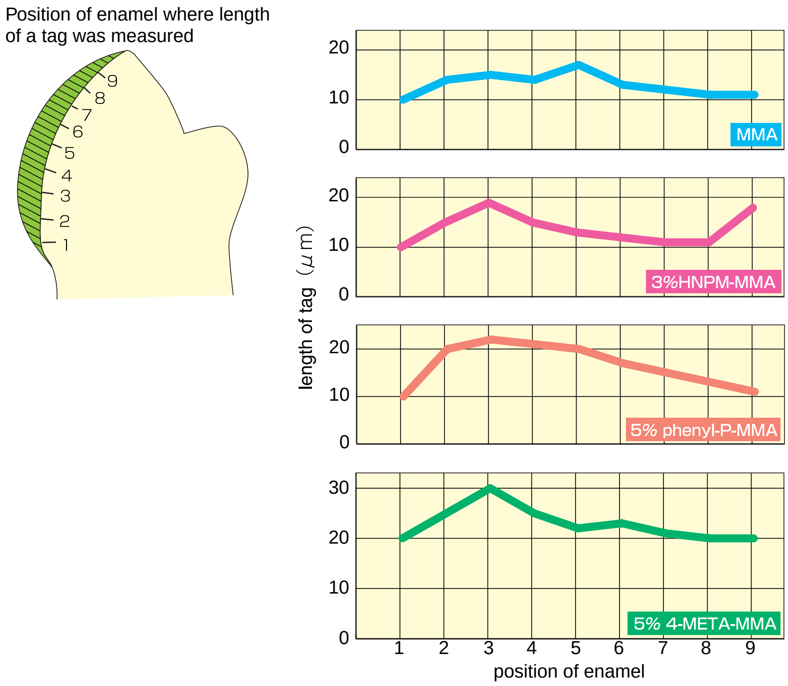
Enamel rods and the interstitial material differ in acid solubility. As a result, when enamel is etched with the Red Activator or Green Activator it develops an irregular scale-like surface.

Due in large part to diffusion-promoting 4-META, Super-Bond C&B creates a strong bond to this prepared enamel (Fig. 3-2) by diffusing deeply into the etched surface to form a resin-impregnated enamel layer.

It is generally believed that this layer renders the enamel caries-resistant. The evidence of this can be seen in the excellent condition of the enamel after removal of bonded orthodontic brackets.

Because Super-Bond C&B contains no inorganic filler, bracket removal is relatively easy and can be accomplished without damaging the tooth structure.

Fig. 3-2 How diffusion promoters affect the length of tags (insoluble by HCl) into enamel
(Nakabayashi N, Miura F, Masuhara A et al.: Studies on dental self-curing resins (22) -Adhesion of 4-META/MMA-TBB resin to enamel- J. Jap. Soc. Dent. App. Mater., 23(61), 88-92,1985)



Human enamel was etched with the Red Activator. Then MMA-TBB resins containing various diffusion promoters were applied.

3.3 Bonding to dental alloys

Super-Bond C&B bonds to dental alloys using two mechanisms: (a) adhesion to the oxide layer on the metal surface, (b) adhesion using VTD. Both mechanisms and their applications are discussed below.

(a) Adhesion to non-precious alloys

Early in the research and development phase, it was discovered that a 4-META/MMA resin, such as Super-Bond C&B, formed strong bonds to non-precious dental alloys (Ni-Cr alloy, Co-Cr alloy, and stainless steel). It is believed that the adhesion is due to a reaction of the 4-META molecule with the surface layer of metal oxide.

Simply sandblasting the surface using 50-micron aluminum oxide is adequate preparation when bonding to non-noble dental alloys (Ni-Cr alloy, Co-Cr alloy, stainless steel, Ti alloy or silver alloy). Super-Bond C&B forms strong bonds to the oxides formed on sandblasted surface of these alloys. Table 3-2

(b) Adhesion to precious alloys

One way to enhance adhesion to noble dental alloys is to prepare the surface before applying Super-Bond C&B using VTD (6-(4-vinylbenzyl-*n*-propyl)amino-1,3,5-triazine-2,4- dithiol).

Thiokol rubber impression materials containing sulfur were known to bond strongly to precious alloy containing Au, Ag or Cu. Inspired by this observation, VDT was developed out of research into monomers containing SH groups (mercapto groups).

(Kojima K et al.: Adhesion to precious metals utilizing triazine dithione derivative monomer, J. J. Dent. Mat., 6(5), 702-707, 1987)

Though chemical compounds containing mercapto groups are usually unstable, VTD demonstrates excellent stability. This stability is attributed to the existence of tautomers of the dithiol and dithion type. Fig. 3-3

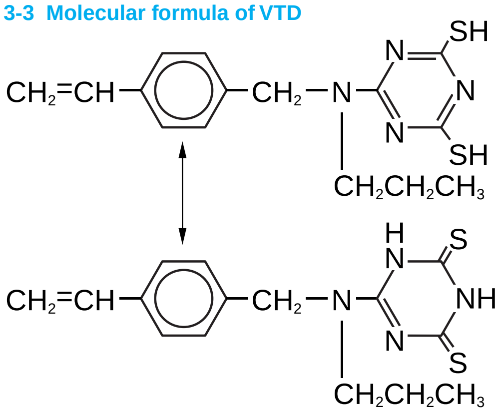
V-PRIMER (which contains VDT) is a bonding primer for Au-Ag-Pd alloys and other precious alloys. Its mercapto groups adhere tenaciously to the alloy surface, and its other vinyl groups react on Super-Bond C&B. The result is excellent adhesion and durability, even to high noble alloys.
Ref. 3-5, Table 3-2, Fig. 3-4

Table 3-2 Bond strength to dental alloys

	Surface treatment after sandblasting	Tensile bond strength (MPa)
Gold alloy Type IV	V-PRIMER	28
	400˚C 5min	25
	Tin-plating	23
Au-Ag-Pd alloy	V-PRIMER	28
	400˚C 5min	24
	Tin-plating	22
Ni-Cr alloy	–	30
Co-Cr alloy	–	31
Cured amalgam	–	10

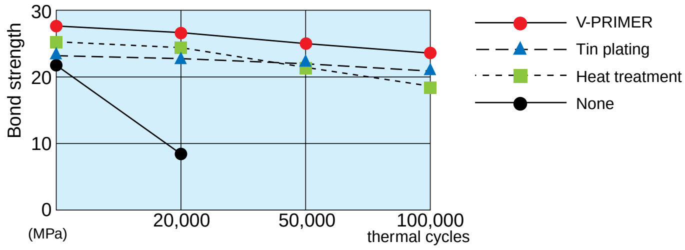
Bonding to a stainless steel rod (after 1,000 thermocycles)

Fig. 3-3 Molecular formula of VTD



6-(4-vinylbenzyl-*n*-propyl)amino-1,3,5-triazine-2,4-dithiol (dithion)
(tautomer of dithiol and dithion type)

Fig. 3-4 Bond durability to Au-Ag-Pd alloy - shear bond strength (MPa)

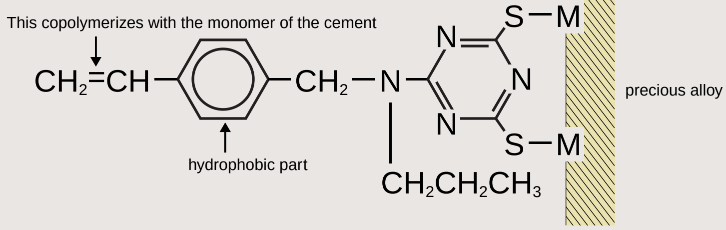


Samples : Au-Ag-Pd alloy. All alloy samples were first blasted with 50 micron aluminum oxide. After various surface treatments (tin-plating, heat-treatment, V-PRIMER, or no treatment) the samples were coated with Super-Bond C&B and a resin composite was applied.

Ref. 3-5

(Matsumura H: The answer to the question on adhesive dentistry - Adhesion to metals, Dental Outlook, 85(6), 1395-1399, 1995)

The bonding mechanism of triazinethiol bonding monomer VTD



3.4 Bonding to porcelain

Before porcelain is bonded using a resin cement, it is usually treated with a silane-based coupling agent. This is a chemical compound with the structure of R-Si-X_3. X are alkoxy groups (for example, methoxy groups (-OCH_3)), which change by hydrolysis to silanol groups (Si-OH). These silanol groups react with silanol groups on the surface of the porcelain in several ways (hydrogen bonding and dehydration condensation) to create a stable siloxane bond (Si-O-Si) and form a hydrocarbon layer on the porcelain surface. Because this hydrocarbon layer includes organic functional groups (for example, $H_2C=C(CH_3)COO-(CH_2)_3$-) that couple with acrylic resin, the film adheres to resin bonding materials.

Porcelain Liner M is a silane-based coupling primer. When liquids A and B are mixed, their methoxyl groups quickly hydrolyze, so it may be applied to the porcelain surface immediately after mixing.

Because of its two-bottle system, Porcelain Liner M is extremely stable. When Super-Bond C&B is applied over this primer, the materials chemically couple. So once it has cured, it creates a strong durable bond to porcelain. Fig. 3-5, Table 3-3

Researchers have reported that because of its 4-META content, Super-Bond C&B in combination with Porcelain Liner M bonds a wide range of porcelains.

Fig. 3-5 Bonding mechanism to porcelain with Porcelain Liner M

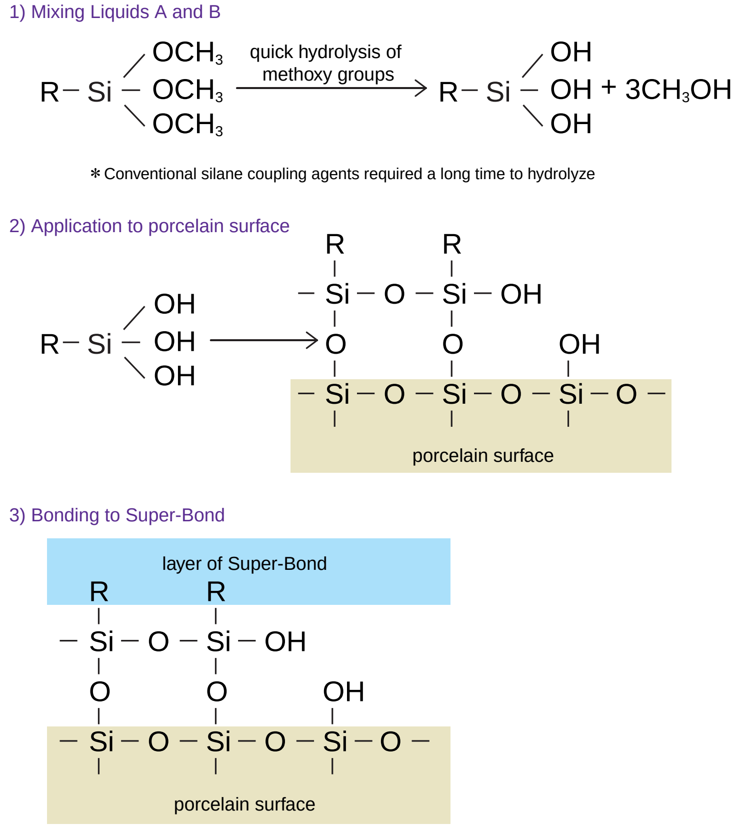


Table 3-3 Bond strength of Super-Bond C&B to porcelain using Porcelain Liner M

1. Bond Strength between VITA Porcelain(ground with #600 Emery paper) and Stainless Steel (MPa)

Thermal cycles (4˚C-60˚C)	1,000	5,000	10,000
Porcelain Liner M, Super-Bond C&B	20	19	13
A bonding agent for porcelain (Imported)	20	12	4
Super-Bond C&B without Porcelain Liner M	8		

2. Bond Strength between VITA Porcelain(glazed surface) and Stainless Steel (MPa)

Thermal cycles (4˚C-60˚C)	1,000	5,000	10,000
Porcelain Liner M, Super-Bond C&B	20	19	9
A bonding agent for porcelain (Imported)	20	5	3

3. Bond Strength between Ceramic Bracket and Acrylic Block (MPa)

Thermal cycles (4˚C-60˚C)	1,000	5,000	10,000
Porcelain Liner M, Super-Bond C&B	20	11	10

4. Application of Super-Bond C&B to vital dentin

4.1 Function of the hybrid layer

An SEM examination of the interface between dentin and Super-Bond C&B reveals the hybrid layer. In this study, the hybrid layer resisted degradation in hydrochloric acid (HCl). Furthermore, the hybrid zone was shown to be different in composition from demineralized dentin ... which consists mainly of collagen (a kind of protein). Collagen dissolves quickly in sodium hypochlorite (NaOCl). But the hybrid layer does not.

(Nakabayashi N, Takarada K: Effect of HEMA on Bonding to Dentin, Dent Mater, 8, 125-130, 1992)

Ref. 4-1

It was reported that the hybrid layer was responsible for the strong resin/dentin bond seen with Super-Bond C&B. However, the hybrid layer might also protect the dentin and function as a substitute for enamel.
The hybrid layer forms a barrier that prevents invasion of oral bacteria and their products toward the pulp. It helps prevent post-operative pain after tooth preparation.

(Nakabayashi N: Function of hybrid layer, Adhesive Dentistry, 13(1), 8-13, 1995)

So the function of the hybrid layer goes far beyond the simple retention of the restoration. In fact, the biological seal it creates in vulnerable prepared dentin, may be the most important contribution of hybridization. This makes it particularly attractive for restoring carious lesions.

(Yasuda N: A Super Adhesion for Caries Treatment, the Quintessence Year Book 1995, 61-69, 1995)

Ref. 4-1

(Nakabayashi N: Function of hybrid layer, Adhesive Dentistry, 13(1), 8-13, 1995)

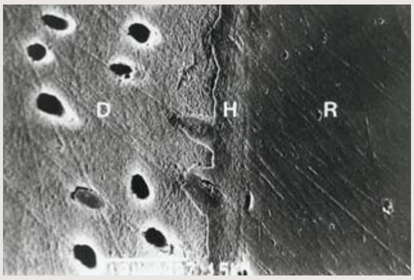


Fig.1
Cross-sectional SEM view of the adhesive interface between 4-META/MMA-TBB resin and bovine dentin pretreated with 10% citric acid-3% ferric chloride (10-3). The specimen was polished with alumina.
R: Resin,
H: Hybrid layer,
D: Intact Dentin

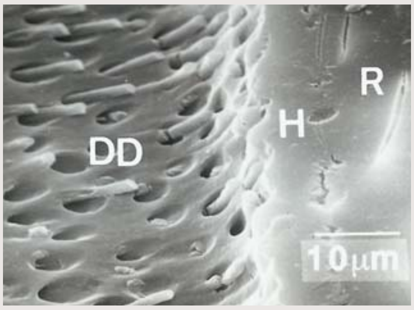


Fig. 2
SEM view of the specimen identical to Fig.1 which was demineralized in 6N hydrochloric acid (HCl) for 30s.
The acid has demineralized the dentin. As a result its surface has dropped below the resin (R) and hybrid layer (H). This photograph clearly demonstrates the acid resistance of the hybrid layer (H).
R: Resin,
H: Hybrid layer,
DD: Demineralized Dentin

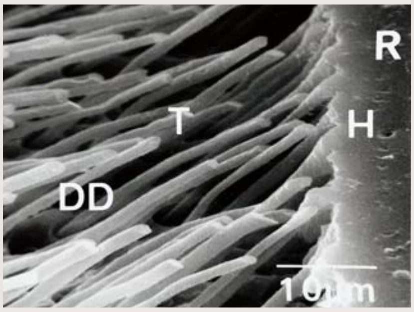


Fig. 3
SEM view of a specimen identical to Fig. 2 which was immersed in 1% sodium hypochlorite (NaOCl) for 10 min in order to remove collagen. Notice that the hybrid layer remains after immersion in NaOCl. This demonstrates that the hybrid layer is more durable than dentin.
R: Resin,
H: Hybrid layer,
DD: Demineralized Dentin
(Resin tags (T) not observed in Fig. 2, appear after removal of collagen)

(Special Contribution)
Function of the hybrid layer

Prof. Nobuo Nakabayashi **Division of Organic Materials, Institute for Medical and Dental Engineering, Tokyo Medical and Dental University**

Depending upon the rate of application, low molecular weight compounds (such as resin monomer) may irritate pulp tissue. Exposure to a large amount of low molecular compound will damage the pulp.
Before discovery of the hybrid layer, the application of self-curing resins on prepared dentin allowed migration of monomer through the dentinal tubules to irritate the pulp. The invasion of bacteria and their toxic products through unsealed tubules could result in pulpal necrosis.
It has been reported that Super-Bond C&B reduces irritation to the pulp by sealing the underlying dentin with a hybrid layer.
A hybrid layer prevents the bacterial invasion into the pulp, and also protects the pulp tissue from the penetration of monomers and bacterial toxins. A hybrid layer acts like a shelter, to protect the pulp from toxic materials and external irritants.
However, for a shelter to function effectively, the shelter must be continuous. Dentists must master the technique of creating a good hybrid layer.
I want to emphasize that when Super-Bond C&B is applied and polymerized on dentin that has been pretreated with Green Activator, the boundary between Super-Bond C&B and dentin cannot be detected. The activated monomers of Super-Bond C&B diffuse (penetrate) into the underlying dentin, and polymerize. The result is the disappearance of a clear resin/dentin interface ... like a photograph that is out of focus. A new layer is created in which resin concentration gradually changes from 100% at the surface to 0%.
When the Super-Bond C&B has polymerized, the dentin is coated with cured PMMA. The restorative material is then placed on this cured PMMA to complete the adhesive restoration.
Disappearance of the dentin/resin boundary means elimination of sites where microleakage can occur. A properly formed hybrid layer can prevent the microleakage-related problems that have occurred in traditional clinical restorations.

4.2 Biological considerations

Effects of 4-META/MMA-TBB resin on pulpal response were reported by Prof. M. Shimono (Department of pathology, Tokyo Dental College.), Prof. C. F. Cox and Prof. S. Suzuki (Department of Restorative Dentistry, University of Alabama at Birmingham).

a) Cytotoxicity test

L-929 cells on a millipore filter were cultured in the presence of various resins. The conditions were as follows; immediately after mixing, 1 minute after mixing, 5 min after mixing, 10 min after mixing, 60 min after mixing, at complete polymerization. The cytotoxic reaction against Super-Bond C&B was observed. The results indicated that the cytotoxicity of 4-META/MMA-TBB resin decreased longitudinally with the time after mixing. Sixty minutes after mixing the samples showed no toxicity.
Ref. 4-2

b) Cell-culture test

Fibroblasts were cultured on a dish with 4-META/MMA-TBB resin for 4 days. The result indicated that although the cells didn't proliferate, they did not die during the test period. On the other hand, the number of fibroblasts diminished on the culture dish with the other cements.
Ref. 4-3

c) Application of Super-Bond C&B to rat and dog pulps

4-META/MMA-TBB resin was applied directly to the exposed pulp of rats' upper first molars. Two weeks later, the rats were sacrificed and pathologically analyzed. Pathological observation suggested the formation of osteodentin and dentin bridge at the interface between 4-META/MMA-TBB resin and pulp tissue.

(Shimono M et al.: New clinical application of adhesive resins available for preserving vital pulps, Practice in Prosthodontics, special volume - Forefront of adhesive dentistry, 27-32, 1991)

Using the same technique, 4-META/MMA-TBB resin was applied to the exposed pulp of anterior and posterior teeth of beagle dogs. One month later, pathological observation showed no pulpal inflammatory reaction and confirmed formation of osteodentin and dentin bridging in some teeth.

(Shimono M et al.: Pulpal response to adhesive resins, Pathology of cure, 1, 195-210, 1993)

d) Indirect pulp capping in humans

4-META/MMA-TBB resin was applied to the cavity floor of human teeth with 1-2mm of dentin remaining over the pulp. Ten to thirty-two days later, no cell infiltration in the pulpal tissue (a sign of inflammatory reaction) was observed.

(Shimono M et al.: New clinical application of adhesive resins available for preserving vital pulps, Practice in Prosthodontics, special volume - Forefront of adhesive dentistry, 27-32, 1991)

e) Direct pulp capping in humans

4-META/MMA-TBB resin was applied directly to the pulp of 31 human teeth and then observed for 7-294 days after the application. No dead space was observed where the 4-META/MMA-TBB resin contacted the pulp. No inflammatory reaction was observed in any sample. However, a slight infiltration of small round cells was seen in one sample, and expansion of blood vessels, congestion and circulatory disturbance were seen in three samples. Macrophages were observed in long-term samples over 60 days. Formation of a dentin bridge was confirmed in 14 samples (long-term samples) out of 31. Ref. 4-4

(Shimono M et al.: Pulpal response to adhesive resins, Pathology of cure, 1, 195-210, 1993)

f) Crown preparation on vital dentin in monkeys

Crown preparations were prepared in adult monkey teeth. The vital dentin was etched with 10% citric acid-3% ferric chloride (10-3), rinsed, and then sealed with a 4-META system. Pulpal responses after 3-10 days showed no symptoms of pulpitis and these pulps presented healing patterns similar to those of pulps lined with calcium hydroxide.

(Suzuki S, Cox CF and White KC: Pulpal response after complete crown preparation, dentinal sealing, and provisional restoration, Quint. Int., 25(7), 477-485, 1994)

Ref. 4-2 Cytotoxic effect of 4-META/MMA-TBB resin

(Morohoshi Y et al.: 4-META/MMA-TBB resin available for preserving vital pulp - part 2 an experimental study on pulpal tissue reaction, Adhesive Dentistry,10(3), 235-239, 1992)

In a study of the cytotoxic effect during the polymerizing reaction, 4-META/MMA-TBB resin showed almost no cytotoxicity.

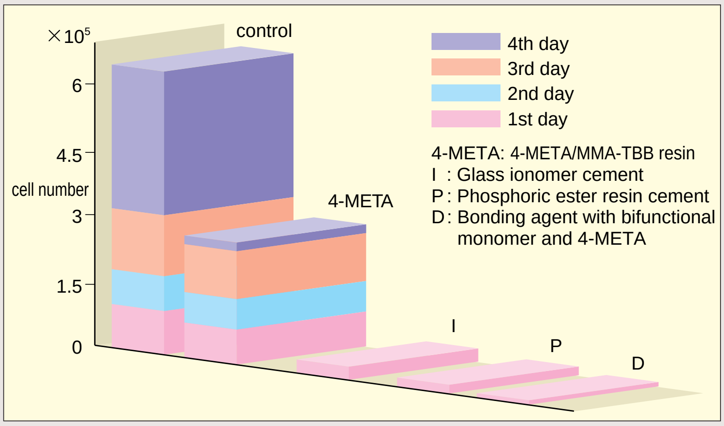
Samples of Super-Bond C&B

Polymerizing time	Score of 9 samples	Evaluation
immediately after mixing	1 1 1 1 1 1 1 1 1	a slight cytotoxicity
1 min	1 1 1 1 1 1 1 1 1	a slight cytotoxicity
5 min	1 1 1 1 1 1 1 1 1	a slight cytotoxicity
10 min	1 1 1 1 1 1 1 1 1	a slight cytotoxicity
60 min	0 0 0 0 0 0 0 0 0	no cytotoxicity
completely polymerized	0 0 0 0 0 0 0 0 0	no cytotoxicity

This table shows weak cytotoxicity during the polymerization reaction of the 4-META/MMA-TBB resin, which significantly decreases with time. In contrast, phosphoric ester monomer/Bis-GMA resin showed moderate cytotoxicity even after 60 min.

Ref. 4-3 Cell-culture test of 4-META/MMA-TBB resin

(Shimono M et al.: New clinical application of adhesive resins available for preserving vital pulps, Practice in Prosthodontics, special volume-Forefront of adhesive dentistry, 27-32, 1991)



Fibroblast cells were cultured for 4 days in dishes with various adhesives. The cells cultured with 4-META/MMA-TBB Resin remained alive during experimental periods, although they exhibited no proliferation. Cells cultured with other adhesives died.

Ref. 4-4

(Inoue T et al.: 4-META/MMA-TBB Resin and Pulpal Response. J. of Society of Endodontia. 14(1), 34-41, 1993)

4-META/MMA-TBB Resin and Pulpal Response

Time	No. of cases	Dentin Bridging	Inflammatory cell	Hypermilia	Macrophage
0 ~ 30days	7	2 (28.6%)	2 (28.6%)	1 (14.3%)	0 (0.0%)
31 ~ 60days	15	7 (46.7%)	0 (0.0%)	4 (26.7%)	3 (20.3%)
60 ~ 294 days	9	5 (55.6%)	0 (0.0%)	0 (0.0%)	4 (44.4%)

Pulpal response when 4-META/MMA-TBB resin systems were used as direct pulp capping agents were histopathologically evaluated. No serious inflammatory reaction of the pulp was observed such as necrosis or abscess formation. Of the 31 teeth treated, there was only two case of slight inflammatory cell infiltration, and five cases with hypermilia. Macrophages were observed at the wound site from 60 days, and increased in number with time. Dentin bridging was observed in 14 out of 31 cases.

4.3 Clinical application to vital dentin

There are many reports discussing the clinical application of Super-Bond C&B to vital teeth.

(Masaka N: AD, Vol. 6, No.3, 177-186, 1988; Ueno Y et al.: AD, Vol. 7, No.3, 181-189, 1989)

Restorative resins were long thought to be toxic to the pulp. The large volume of reports show that use of Super-Bond C&B on vital dentin was established step-by-step only after years of clinical documentation.

Ref. 4-5

Both direct and indirect pulp caps have been performed using Super-Bond C&B in one-step and two-step procedures.

(Masaka N: Adhesive treatment of crown preparations 2. Restoring the tooth with an exposed pulp due to caries, The Nippon Dental Review, 587, 1-3, 1991)

However, the author stressed that adhesive pulp caps are indicated only for healthy pulps. A careful examination of pulp should be performed before treatment.

(Masaka N: Dental Outlook, 86(2), 425-430, 1995; Iwaku M: Dental Diamond, 20(14), 80-87, 1995; Iwaku M et al.: Clinical Technique Series-2, The Nippon Dental Review, 1996; Manabe A: Practice in Prosthodontics, 30(3), 276-288, 1997)

When bacterial infection is suspected, application of a mixture of 3 antibacterial agents has been proposed by Prof. Iwaku et al. This treatment has proved effective against a broad spectrum of pathogens.

After application of these antibacterial agents, it is necessary to seal the disinfected area with an adhesive resin that forms a protective hybrid layer. Iwaku (1997) indicated as follows: A tight marginal seal between cavity walls and filling materials must be maintained to protect the dentin and pulp against bacterial reinfection. Dentists should use good adhesive restorative materials, and master their clinical usage.

(Iwaku M: New Biological Approach to Caries Treatment: Lesion Sterlization and Tissue Regeneration (LSTR), 2nd International Seminar for Japan/Thailand Core University Program in Dentistry, 14-23, 1997)

Another trial was reported by Kudoh (Assistant Professor, Iwate Medical University) using Super-Bond C&B in which the Polymer powder was blended with an antibiotic (Vancomycin).

(Nakamura M et al.: Is it possible to prevent hypersensitivity of exposed dentin by applying adhesive resin?, The Nippon Dental Review, 642, 125-137, 1996; Nakamura M: My clinical cases for root surface caries, AD, 15(2), 175-180, 1997)

The prevailing view is that the dentin and pulp must be considered to be one organ (the dentin/pulp complex). Unfortunately, many dentists have difficulty shifting their focus from the treatment of the exposed pulp to the protection of freshly cut dentin.

It has been suggested that if complete removal of deep caries may result in pulp exposure, the dentist might stop removal of the carious dentin before exposure, apply antibacterial agents, and wait for recovery of pulpal vitality.

(Manabe A: Preservation of dental pulp-2 Pulp diagnosis in various clinical cases, Practice in Prosthodontics, 30(3), 276-288, 1997; Masaka N et al.: Adhesive made a change of pulp preservation, THE NIPPON Dental Review, 655, 63-109, 1997)

It has also been suggested that the treatment of caries and the restoration of the tooth should be thought of as two distinct operations. The most important role of an adhesive resin is not to retain the restoration, but to create a biological seal (such as a hybrid layer) that will protect the prepared cavity surfaces from bacterial irritation.

The concept of using adhesive resins to form a protective shield (or epithelium) has been referred to as "Super-adhesion". Since poor sealing may result in bacterial contamination of the cavity, possibly leading to pulp damage, it has been suggested adhesive resins should be routinely applied to cut dentin as part of the "caries treatment" phase. This will create a protective resin-impregnated layer, regardless of what restorative procedures are planned.

(Masaka N: Adhesive treatment of crown preparations 7.Protecting the exposed dentin surfaces of vital teeth, Nippon Dental Review, 592, 1-3, 1992; Nakabayashi N et al.: Making A Super Adhesion: Artificial Enamel, Quintessence, 14(1), 42-46, 1995; Yasuda N: Caries Treatment using a Super Adhesion, the Quintessense Year Book 1995, 61-69, 1995; Katoh Y et al.: Restorative target to endogenous defects, Special Issue of Practice in Prosthodontics, 93-98, 1997)

Super-Bond C&B's components are highly biocompatible and least-injurious to dental tissue. It effectively seals the prepared tooth surfaces with a protective hybrid layer. These features make Super-Bond C&B highly reliable for use on vital teeth.

Ref. 4-5

(Masaka N et al.: THE NIPPON Dental Review, 586, 1-3, 1991)

The pulpal safety of 4-META/MMA-TBB Resin was demonstrated clinically.

From 1980: Surface of vital teeth was lined with inorganic cement. Preparation was limited to enamel.

From 1983: Prepared surface of vital teeth was protected with PALFIQUE LINER.

From 1987: Pulpal safety of 4-META/MMA-TBB Resin was demonstrated in the adhesive amalgam technique.

From 1988: Prepared surface of vital teeth was directly coated with 4 META/MMA-TBB Resin.

From 1989: Direct pulp capping with 4-META/MMA-TBB Resin was performed without postoperative sensitivity.

5. How to use Super-Bond C&B

5.1 Surface treatment

In order to get the best results from Super-Bond C&B, the adhesive surface must be properly treated before bonding.

a) Treatment of the tooth surface (Cleaning)

Clean the tooth surface to remove plaque, calculus and biofilm. Do not use fluoride-containing prophy paste or eugenol-based agents (eugenol may inhibit polymerization). If these materials are accidentally used, the surfaces must be thoroughly cleaned to remove the chemical residue.

Though some reports suggest that temporary cements, such as eugenol, non-eugenol, and HY-based cements, will not significantly affect the bonding of Super-Bond C&B, these cements must be completely removed from the surface using a degreasing solution, ethanol or water with cotton ball.

If a sodium hypochlorite agent is used to clean or sterilize the cavity/root canal, do not apply for a prolonged period or bond strength will drop. Application time should be kept less than 30 seconds. DO NOT use higher concentrations of sodium hypochlorite agent (i.e. AD gel). Even short-term application of AD gel will seriously compromise the performance of Super-Bond C&B. (See Q&A 4)

(Prevent contamination and moisture)

After the appropriate treatment of the adhesive surface, keep the surface dry. Do not contaminate with saliva, blood, water, oil, or humid breath. We recommend the use of dental gloves and rubber dam, as they reduce the chance of the surface contamination. (At the very minimum isolate the tooth with cotton rolls.)

(Application of Activators)

After cleaning, apply the Red Activator or Green Activator to the tooth surface. Dentin surfaces must be treated with the Green Activator. Enamel surfaces can be treated with either the Red Activator or the Green Activator.

If the application is too short, the tooth surface will not be adequately modified. If the treatment is too long, the tooth surface may so severely modified, that it becomes brittle or so deeply demineralized that the 4-META/MMA-TBB monomers cannot penetrate completely through the demineralized dentin.

Therefore, it is important to apply the activators for an optimal treatment time. Fig. 5-1 After treatment, the activator must be thoroughly rinsed off. Once the Green Activator has been applied to dentin, sodium hypochlorite must not be applied.

Fig. 5-1 Optimal Time for Tooth Surface Treatment

	Green Activator	Red Activator
Enamel	30～60sec	30sec
Dentin	5～10sec	—

Q&A 5

Q: If Super-Bond C&B initiates polymerization from the dentinal subsurface, which contains water, should the tooth surface be moist when the adhesive is applied?

A: No, the tooth should be dried before bonding. Even after drying, the surface will remain slightly moist. The bonding mechanism of Super-Bond C&B is different from those bonding systems that require a wet-bonding technique. When bonding with Super-Bond C&B, do not intentionally produce a moist surface. (Refer to Q&A 3)

Q&A 6

Q: If the tooth surface becomes contaminated with saliva after the Green Activator has been applied and washed off, how should the tooth be treated?

A: If the surface remains contaminated when it dries, the bond strength of Super-Bond C&B will drop. Rinse the surface thoroughly with water and dry it. Then proceed with the remaining steps in the bonding procedure. (Re-treatment with "Green Activator" will reduce the bond strength to dentin.)

(Hiranuma K, Watanabe I, Nakabayashi N: Effect of Saliva Contamination on Adhesion of 4-META/MMA-TBB Resin To Teeth Pretreated with 10-3, AD, 10(3), 197-202, 1992)

Q&A 7

Q: Does the application of Saforide to the tooth lower the bond strength of Super-Bond C&B?

A: Saforide contains $Ag(NH_3)_2F$, which is clinically used to prevent caries and treat dentin hypersensitivity. Saforide will not compromise the bond strength. It has been reported that the fluoride forms fluoroapatite from hydroxyapatite and that the silver ion seems to coagulate and stabilize the collagen fibrils, resulting in improved bond strength.

(Fujii B, Narikawa K: Dental Outbook 85(5), 1081, 1995; Yamamoto K: Japan J Conserv Dent, 34(1), 164-182, 1991)

Q&A 8

Q: When etching enamel, how do I decide which Activator to use (Red or Green)?

A: Though both activators are effective on enamel, we recommend the Red Activator for acid-resistant fluoridized enamel. If both enamel and dentin surfaces are present, we recommend that the Green Activator be applied to both enamel and dentin. This will avoid any possibility that the Red Activator (phosphoric acid) will contact the dentin surface.

b) Treatment of metal surfaces

To achieve the best bond to dental alloy, the pretreatment must match the specific metal. In all cases, the metal surface should be air-abraded with 50 micron aluminum oxide to increase the bonding area. If sandblasting is impossible, use an abrasive point to prepare a fresh, rough surface

The sandblasted surface must be clean and dry during bonding. Contamination with oil, saliva or blood will lower the bond strength. Ideally, sandblasting should be performed immediately before bonding. (After sandblasting, ultrasonic cleaning is also effective.)

(Non-precious metal alloys)

Non-precious metal alloys, such as Ni-Cr, Co-Cr, Ti alloys, and stainless steel oxidize easily. Therefore, sandblasting is sufficient to produce good bond strength to alloys. It is also effective for preparing silver metal.

(Precious metal alloys)

Precious metal alloys (including Au-Ag-Pd alloy) are more resistant to oxidation. Sandblasting is not sufficient pretreatment when bonding to precious metal alloy. In 1994, a pretreatment primer for precious metal "V-PRIMER" was developed, which contains VTD 6-(4-vinyl benzyl-*n*-propyl)amino-1,3,5-triazine-2, 4-dithol. After sandblasting the precious metal, pretreatment with V-PRIMER is a simple, effective way to enhance bonding.

Other ways to improve bond to precious alloys include heat-treatment to encourage formation of an oxidized layer or electro tin-plating.

Q&A 9

Q: Is V-PRIMER effective for other adhesive materials?

A: We recommend V-PRIMER only for use with Super-Bond. Though V-PRIMER improves the bond strength to precious metal of other adhesive materials, it is less effective than with Super-Bond C&B.

Q&A 10

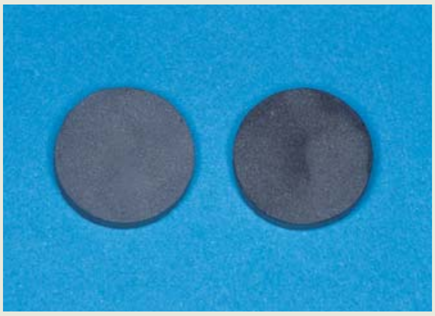
Q: V-PRIMER evaporates immediately on the metal surface. Are multiple applications of V-PRIMER needed?

A: No. A single application of V-PRIMER produces the best results. Multiple coats will decrease bond strength to metal. Avoid multiple coats.

Q&A 11

Q: When V-PRIMER is applied, irregular stripes are sometimes observed on the primed surface. Do these stripes adversely affect the bond strength?

A: V-PRIMER contains acetone, which evaporates quickly after the application of the primer. This may cause the treated surface to appear striped. However, the stripes do not influence the bond strength.



Left:Surface blasted with aluminum oxide.
Right:Surface blasted with aluminum oxide and then treated with V-PRIMER.

C) Treatment of porcelain surfaces

When porcelain is bonded with Super-Bond C&B, the surface is first treated with a silane coupling agent (Porcelain Liner M). The important points during pretreatment of the porcelain surface are as follows:

(Clean the porcelain surface)

The ceramic surface must be cleaned before bonding. Any of the following techniques may be used:

- Ultrasonic cleaning
- Abrasion with a diamond point or an abrasive blaster (If abraded, the debris on the surface must be washed away with a water spray. After washing, the surface is dried.)
- The Red Activator can also be used to remove organic contaminants on the surface.

(Treatment with Porcelain Liner M)

Mix Liquid A and Liquid B, and immediately apply to the surface. If the liner pools, the surface should be gently air-dried. Heating the treated surface improves the bond strength. Table 5-2

(Takahashi H et al.: Question & Answer in adhesive dentistry, Bonding to ceramic, Dental Outlook, 85(6), 1404-1406, 1995; Babazono K: Activator for silane coupling agent using an electric bulb, Dental Outlook, 88(5), 1225-1227, 1996)

d) Treatment of resin surfaces

Super-Bond C&B bonds well to acrylic resin such as denture base resin, and to polycarbonate resin used for orthodontic brackets, temporary crowns etc.

The surface must be cleaned to remove contaminants, and the Super-Bond C&B monomer should be applied to the surface prior to the bonding procedure.

However, it is more difficult to bond to resin composite (unless, of course, the surface is still covered by an unpolymerized layer). For example, it is difficult to bond to a fractured resin veneered crown, to a direct resin composite, or a composite resin denture tooth. Cementing a resin jacket crown is also difficult.

However, these materials have a large inorganic filler content, and these fillers can be bonded to using the porcelain bonding technique. The surface is first ground to remove the debris and expose a fresh composite surface. Then it is cleaned using the Red Activator, rinsed and dried. Porcelain Liner M is applied.

(Takahashi H et al.: Porcelain, Resin repair technique, Ishiyaku Publishers Inc., 1995)

Before application of the Porcelain Liner M, air abrasion of the surface with alumina can also improve the bond strength.

Table 5-2 The effect of heating on the bond strength of Porcelain Liner M treated surfaces

Heating Methods	Treatment Time (min.)	Bond Strength*1 (MPa)
No Heating	—	13
Heating with Dental Blower*2	1	19
	2	20
Heating with Hair Dryer*3	1	17
	3	21

*1 Bond VITA559 Porcelain, Thermocycle 10,000 times
*2 Product of Morita, 120~130˚C
*3 Sold for household use, 70~80˚C

Q&A 12

Q: How to use Porcelain Liner M and V-PRIMER when bonding to a surface that includes both porcelain and metal?

A: When reparing a fractured ceramometal crown, it is often necessary to bond to a surface that consists of both porcelain and metal. In such a case, a separate treatment is required for each surface. The metal surface should be treated with V-PRIMER, and the porcelain surface treated with Porcelain Liner M. It is sometimes very difficult to separate clinically these treatments. However, care should be taken when using these primers, especially the V-PRIMER. If V-PRIMER accidentally contacts the porcelain, bond strength will drop. (This is true whether the V-PRIMER is applied before or after the Porcelain Liner M.)
For best esthetics, opaque Polymer is recommended for application to the metal surface. Clear Polymer is recommended for use on the porcelain to create an inconspicuous margin.

Interaction of Porcelain Liner M and V-PRIMER

Base material	Primary coating	Secondary coating	Bond Strength (MPa)*
Gold/Silver/Palladium alloy	V-PRIMER	—	25
	Porcelain Liner M	V-PRIMER	24
	V-PRIMER	Porcelain Liner M	25
Porcelain	Porcelain Liner M	—	22
	Porcelain Liner M	V-PRIMER	12
	V-PRIMER	Porcelain Liner M	16

* Composite resin is bonded with Super-Bond after coating of Primers and bond strength is measured after 1,000 times of thermal cycle.

5.2 Handling of Super-Bond C&B

a) Application of the activated liquid on the surface

To create the highest possible bond strength, Super-Bond C&B must intimately contact all surfaces to be bonded. One coating of the activated liquid (the mixture of the Monomer and Catalyst S) on the tooth surface prior to the application of Super-Bond C&B, improves the bond strength. This step is especially important if you are using the brush-dip technique.

*In the bulk-mix technique, if the Super-Bond C&B is applied in a very fluid condition, it will thoroughly wet the surface without a precoating of activated liquid. So prewetting the surface may be eliminated. Nevertheless, even when using the bulk-mix technique, applying the activated liquid to vital dentin before cementing will improve the bond by helping overcome the influence of pulpal fluid contamination.

b) Basics for handling

The basics for handling Super-Bond C&B are:

- preparing the adhesive mixture while the Activated Liquid is still active,
- applying the adhesive mixture to the surfaces before the polymerization reaction advances, and
- positioning the surfaces and holding them immobile till the curing reaction is complete.

After all the preparation procedures are finished, the surfaces to be bonded are pretreated, and the materials and instruments arranged, then Super-Bond must be mixed and the bonding operation completed immediately.

c) Selection of application techniques

Super-Bond C&B can be applied in two ways. One method is the brush-dip technique. The other is the bulk-mix technique.

The brush-dip technique is ideal for successive applications on several comparatively small areas. The brush is dipped into the Activated Liquid and then touched to the Polymer powder in another well. A small ball of powder will be picked up on the wet tip of the brush. (The liquid and powder mix together to form an adhesive ball.)

In the brush-dip technique the Polymer powder and Activated Liquid are not mixed in the well, therefore the brush-dip operation can be repeated for about 5 min ... as long as the Activated Liquid remains active. The curing time in the brush-dip technique is 5 to 6 minutes at 37˚C, faster than in a bulk-mix technique.

The bulk-mix technique is used for application to large areas, which are difficult to cover with the brush-dip technique. In the bulk-mix technique the polymerization reaction starts the instant the Polymer powder is mixed with the Activated Liquid. Therefore, the adhesive mixture should be used immediately after mixing. In the bulk-mix technique, the Powder/Liquid ratio is lower than that of the brush-dip technique. This allows enough working time and good seating.

Precautions for each bonding technique are as follows: More technical information is presented in the Instructions.

(Brush-dip technique)

1. Use a clean dispensing dish. It is not necessary to chill the dish in the refrigerator.

   *Caution. The dispensing dish should not be used for other materials. Contamination caused by other systems may inhibit polymerization or cause discoloration.

2. Fresh Polymer powder should be dispensed from the jar each time. Do not use old powder left over from other procedures. Do not return leftover powder to the jar, because it may have been contaminated by the Activated Liquid.

3. If the Catalyst S has not been used for an extended period, the first drop in the tip of the syringe may have lost potency due to exposure to air. Therefore, if this is the first use of a new catalyst syringe or the catalyst has not been used for a long time, add a second drop of catalyst to the monomer.

4. The standard ratio of Monomer/Catalyst S is 4 to 1. However, some orthodontists prefer a ratio of 3 to 1. This reduces the curing time but does not affect the polymerization reaction or the bonding performance. (See e))

5. The mixed Activated Liquid reacts with oxygen, gradually decreasing its activity. The Activated Liquid should be used quickly, at the latest within 5 min after mixing.

   *If more Activated Liquid is needed, the remaining liquid should be wiped out of the dish, and a fresh mix prepared. Do not add the new Monomer and Catalyst S to the old liquid.

6. The brush with the pointed end Brush Tips (White) should be used in the brush-dip technique. After each application, use a gauze to clean the resin off the brush before again dipping it into the liquid.

   *Disposable tips (white L), and (white S) are available for the brush-dip technique.

7. The Brush Tips (White) are for one-time use. If any other multi-use brush is used, clean the resin out of the brush using a solvent after completing the procedure. .... Before drying, form the brush tip into a sharp point.

(Bulk-mix technique)

1. The dispensing dish must be cooled in a refrigerator, and taken out just before use. Chilling the dish allows a longer working time. (See e))

   *When the mixing dish is removed from the refrigerator, its temperature will be below 10˚C. As a result, moisture may condense in the dish. If this occurs simply remove the moisture with a paper towel or air-blast.

2. Activated Liquid should be prepared immediately before mixing and it should be used immediately.

3. If the Catalyst S has not been used for an extended period, the first drop in the tip of the syringe may have lost potency due to exposure to air. Therefore, if this is the first use of a new catalyst or the catalyst has not been used for a long time, add a second drop of catalyst to the monomer.

4. Select an appropriate Polymer type to control the working time, and/or change the Polymer powder/Liquid ratio.

   *if a large prosthesis being cemented or the room temperature is warm, use a L-Type Polymer and/or reduce the standard Powder/LIquid ratio, but never below half, to extend the working time. (See d))
   *Decrease of the Powder/Liquid ratio extends the working time. But you should note that it also extends the curing time. (See Table 5-4)

5. The Activated Liquid in the dispensing dish and the Polymer powder are mixed for a few seconds with a disposable brush. Then, using the brush, the slurry is immediately applied to the surface.

   *Do not mix the Powder and Liquid for more than a few seconds. The mixture must be used during the slurry or sol stage. After that, the mixture starts threading. At this stage, handling properties deteriorate. Increased adhesive film thickness will cause poor seating and a low-quality hybrid layer.

d) Influence of the Powder/Liquid ratio

If the Powder/Liquid ratio is cut up to half (That is, if just half the powder is added to the activated liquid), the bonding properties will not be affected. Therefore, the working time can be extended by reducing the Powder/Liquid ratio. In this case it is convenient to use the Measuring Spoon (Small). But you should note that reducing the powder also extends the curing time.
Conversely, when you want to shorten the curing time and still assure reasonable working time, use a Polymer L-Type and increase the Powder/Liquid ratio to 1.2 using the Measuring Spoon (Large). Table 5-3

e) Influence of the Monomer/Catalyst ratio

The standard ratio of Monomer/Catalyst S is 4/1. However, the curing time of Super-Bond C&B can be adjusted by changing this ratio. Table 5-4 shows the influence on curing time and bond strength to a metal and dentin. Table 5-4
As the Monomer/Catalyst ratio increases from 2/1 to 6/1, the curing time is prolonged but the bond strengths to metal and dentin remain unaffected. It may be useful to change the Monomer/Catalyst S ratio in clinical use. For example, many orthodontists commonly use Super-Bond C&B at the ratio of 3/1.

f) Influence of temperature

Temperature influences both working time and curing time. As the temperature drops, the time until threading is extended. Working time is influence both by the temperature of the mixing dish and the surrounding temperature. A method for lowering the surrounding temperature has been described. Fig. 5-1

(Manabe A et al.: Prolongation of Working-time for 4META/MMA-TBB Resin Part 1. Effectiveness of "Super-Bond Station" in Practical Use, Adhesive Dentistry, 12(1), 49-54,1994; Manabe A: Feature and clinical use of Super-Bond C&B, Dental Magazine, 87, 48-54, 1996; Watanabe T et al.: Prolongation of Working-time for 4-META/MMA-TBB Resin, Adhesive Dentistry, 15(2), 134-140, 1997)

Table 5-3

a) Effect of Powder/Liquid Ratio on Working Time and Curing Time in Bulk-mix Technique

	Polymer	Opacity	Working time (16˚C)			Curing time (37˚C)		
			1.2 cup (sec.)	1 cup (sec.)	0.75 cup (sec.)	1.2 cup (min.)	1 cup (min.)	0.75 cup (min.)
Normal Type	Clear Esthetic	Trans-lucent	——	70	180	——	7.5	14.5
Normal Type	Opaque Ivory Opaque Pink	Opaque	——	100	170	——	8.5	17
L-Type	L-Type Clear L-Type Esthetic	Trans-lucent	110	150	230	6	8.5	15.5
L-Type	L-Type Radiopaque	Radio-Opaque	120	200	270	7	9.5	18

*1 Available time before threading starts (namely, in slurry or sol state) at 16˚C
(Note) 1 cup stands for the standard Powder/Liquid ratio.
1.2 cup means: the Powder/Liquid ratio is 120% of the standard ratio.
The same holds true for other ratios.

b) Polymer Types and their Curing Times in Brush-dip Technique

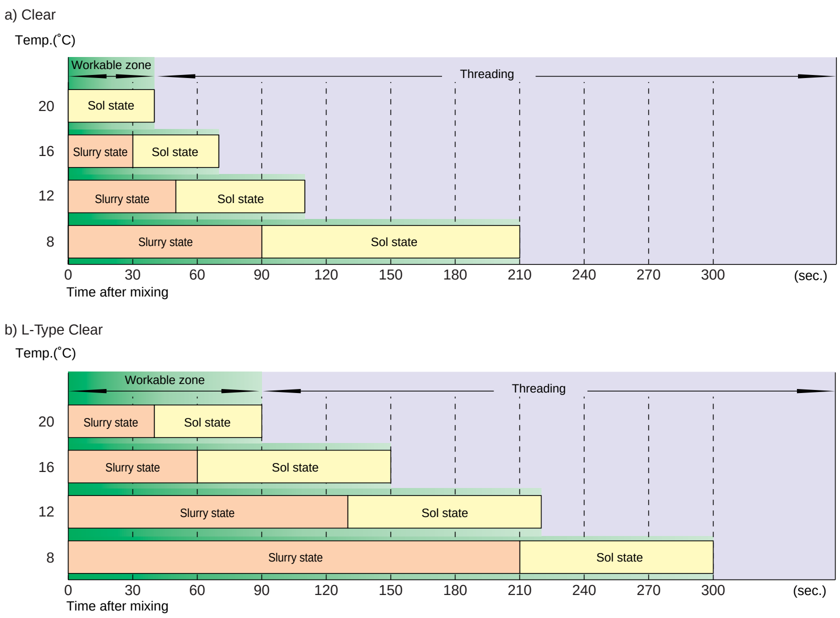
	Polymer	Opacity	Curing time (37˚C) (min.)
Normal Type	Clear Esthetic	Trans-lucent	5
Normal Type	Opaque Ivory Opaque Pink	Opaque	5.5
L-Type	L-Type Clear L-Type Esthetic	Trans-lucent	5.5
L-Type	L-Type Radiopaque	Radio-Opaque	6

Table 5-4 Influence of the ratio of Monomer/Catalyst S

Monomer / Catalyst S (drop) (drop)	Curing time at 27˚C*1	Tensile bond strength (MPa)	
		Au-Ag-Pd Alloy*2	Bovine Dentin*3
2 / 1	6'00"	18	13
3 / 1	6'30"	18	14
4 / 1	7'40"	22	14
5 / 1	8'30"	27	17
6 / 1	9'20"	19	14

(Polymer powder (Clear) of Super-Bond C&B)
*1 Brush-dip technique
*2 Ground with #2000 Emery paper, primed with V-PRIMER, Thermocycled 2,000 times
*3 Treated with Green Activator for 10 sec, bond strength after storage in 37˚C water for 1 day

Fig. 5-1 Effect of Temperature on Working Time in Bulk-mix Technique



g)Proper selection of the Polymer (powder) type

Seven types of Polymers are available for Super-Bond C&B, including those sold separately. They can be divided into 2 basic classes, the normal type and the newly developed L-Type. Polymer L-Type is characterized by a modified particle surface that gives a longer working time without substantially changing the curing time. L-Type is also used to speed up curing by increasing the Powder/Liquid ratio to 1.2. (See Table 5-3)
Refer to the following list to select the best Polymer for your application. (See Table 5-3 and Fig. 5-2)

❶ Clear and **L-Type Clear**
Fine PMMA powder without pigment. When cured, its medium translucency and inconspicuous shade is ideal for temporary splinting of loose teeth, creation of temporary prostheses using a resin tooth or extracted tooth, or direct bonding of orthodontic brackets with the Brush-dip technique.
When the normal Clear polymer is used in the Bulk-mix technique, the working time before threading is rather short. Here, the L-Type Clear polymer is preferable, because it allows more working time.

❷ Esthetic and **L-Type Esthetic**
Tooth-colored Clear powder. When cured, its color is ivory with some translucency and little opacity. It is used for prostheses that require an esthetic appearance. Curing time and workability are similar to that of the Clear powder and L-Type Clear powder respectively.

❸ Opaque Ivory
Opacity is produced by specially prepared pigments. The powder creates an extremely opaque cement film that is highly effective in masking metal surfaces. It is recommended for use when metal show-through might affect aesthetics (as when cementing inlay or adhesion bridges), or when repairing fractured prostheses with exposed metal. Its working time is slightly longer than Clear powder, but shorter than L-Type Clear.
The Opaque Ivory powder is widely used for routine cementation. Due to its opacity, any excess cement is extremely visible, which facilitates removing it. (See Table 8 and Fig. 4 in "Data and References".)

❹ Opaque Pink
Pale pink color is added to Opaque Ivory. This powder was originally intended for repairing denture bases, but it can be used for the same purposes as the Opaque Ivory. Some dentists prefer it to the Opaque Ivory as its pink color reflected on the surrounding teeth produces a more natural shade. Its handling and setting properties are similar to those of the Opaque Ivory.

❺ L-Type Radiopaque
This powder contains highly radiopaque filler. When it is used in the Bulk-mix technique under the standard Powder/Liquid ratio, the cured adhesive shows radiopacity equivalent to enamel. (See Table 5-5 and Ref. 5-1) This Polymer combines the opacity of Opaque Ivory with the radiopacity of the former Radiopaque polymer. It creates a natural tooth-color and allows a longer working time for easier handling. However, it cures slightly more slowly than the Clear powder. For faster curing, use the Powder/Liquid ratio of 1.2.

Fig. 5-2 Type of Polymer and its working time

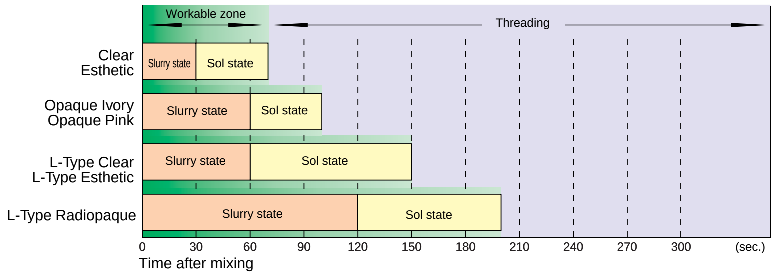


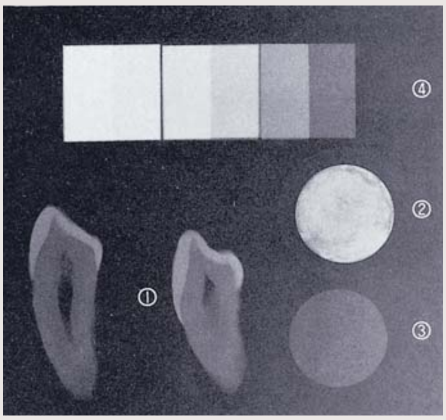
Table 5-5 Radiopacity using Polymer (L-Type Radiopaque)

Material	Technique	Ratio to Standard Powder/Liquid Ratio	Radiopacity*1 (%)
Super-Bond C&B using Polymer L-Type Radiopaque	Bulk-mix technique	1.2	260
		1	210
		0.75	160
	Brush-dip technique		330
Enamel			180
Dentin			120

*1 Radiopacity of Aluminium is regarded as 100%
(Test Method is based on ISO 4049)

Ref. 5-1

(Nakamura M, Matsumura H: Controlling postoperative dentinal hypersensitivity with an adhesive resin, 642, 125-137, 1996)



①Human premolar (1mm thick)
②Super-Bond Polymer(Radiopaque)
③Photo Cleafil A
④Aluminum Plate(1-6 mm thick)

Super-Bond using Polymer (Radiopaque) has an equivalent or higher radiopacity than enamel. When it is applied at bottom of cavity, it is easily distinguished from intact dentin or a carious lesion.

5.3 Post-treatment

The curing time of Super-Bond C&B at 37˚C is 5 to 6 minutes with the brush-dip technique, and 7 to 8 minutes with the bulk-mix technique using the standard Powder/Liquid ratio.
However, as already discussed the curing time will be extended if you use a lower Monomer/Catalyst S ratio or a lower Powder/Liquid ratio.
After seating the restoration, hold it in position. The bond strength will decrease if the restoration moves during curing.
In orthodontic treatment, arch wire can be set ten minutes after bracket bonding. When cementing a prosthesis, the dentist can perform the next procedure after 10 to 15 min. The dentist should tell the patient, however, to avoid heavy biting during the day of cementation.
Because Super-Bond C&B provides high bond strength and the cured material has tenacity and some flexibility, it becomes more difficult to remove excess resin after it has cured.
How to remove excess resin easily:

1. The areas you do not want to bond should be protected with a resin separator, protection film (Parafilm) and/or gingival cord.
2. Mix the Super-Bond using the Opaque Polymer to make the excess resin easily identifiable.
3. Immediately after cementation, roughly wipe off the excess resin with a cotton pellet or brush soaked in alcohol. Resin in the proximal area should be removed before curing using dental floss or an interdental brush. Excess resin in the gingival sulcus should also be removed. During removal of the excess resin, have the patient bite a wood block to hold the restoration immobile.
4. Do not attempt to remove excess cement during the threading stage. It is very difficult to handle the resin while it is threading. Even at this viscous stage the bonding layer has already been established. There is virtually no chance that removing excess cement flash will accidentally pull the resin from beneath the restoration. After the threading stage is finished, scrape off the excess resin with hand instruments.
5. On the surface where a separator was applied, it will be easy to scrape off the excess using an instrument for cement removal.
6. It is also very easy to remove the excess resin on the protection film. It will come off when the film is removed.
7. A few days later, the patient should be recalled and the restored teeth should be checked again for resin.

(Clinical case showing removal of excess resin)


①A bridge before setting


②A resin separator. Apply the separator on any metal or porcelain surfaces that may contact the resin.

③A protection film, Parafilm.* Cut the Parafilm 1 cm wide and roll around the pontic of the bridge.


④The bridge after applying a resin separator and Parafilm.


⑤Applying V-PRIMER to the inside of the crowns.


⑥Applying Super-Bond C&B (Opaque Pink) to the inside of the crowns.


⑦The bridge should be rapidly seated.


⑧An instrument for removing excess resin.


⑨The excess resin should be removed with a brush or a cotton pellet soaked in alcohol. As much as possible of the excess resin (especially in the proximal area) should be removed at this stage.


⑩After the resin has cured, excess on the surface that was coated with the resin separator can be easily removed using a resin cement remover.


⑪Remaining resin in the proximal area will be removed when the Parafilm is removed.


⑫The bridge after the excess resin has been completely removed.

*American National Can Co.. (You can generally get it at a shop for chemical laboratory supplies)

(Cleaning the instruments)

After it has cured, it is very difficult to remove residual resin from the brush or the dispensing dish. You should carefully clean all instruments before the residual resin cures.

a) Brush

Immediately after use, wipe the resin off the brush tip using a gauze. It is easy to clean the brush with acetone. Keep the brush tip pointed. If the resin has cured on the brush, the brush should be immersed in acetone till the resin swells. Then it is easy to clean.

b) Dispensing Dish

Wipe the residual resin out of the dispensing dish using tissue paper or gauze immediately after use. If the resin has cured, the dish should be washed with acetone, or stored in water overnight.

6. Clinical applications

1. Orthodontic application

Super-Bond's excellent adhesive properties to enamel, metal, plastic and porcelain make it useful for bonding a wide variety of orthodontic appliances.
It is also efficacious for bonding buccal tubes to teeth used with headgear, canine-to-canine retainers and rapid expansion appliances.
Super-Bond is a popular adhesive for the Direct Bonding System (DBS) which reduces the risk of caries under bands and eliminates band-related periodontal damage. Super-Bond is an MMA-based adhesive resin that contains no inorganic fillers in the Clear Polymer powder. Although it demonstrates excellent adhesion, it is easy to manually debond the brackets.

Clinical hints

In orthodontic applications Super-Bond is generally applied using a brush-dip technique.

①Before it is dipped into the Activated Liquid (Monomer liquid mixed with Catalyst S) the tip of a brush should be cleaned of any Polymer residue and formed into a fine point. (Wiping the brush tip after each application will improve its efficacy and avoid contamination of the Activated Liquid)

②Before any Polymer powder is applied, the surface should be coated with just the activated liquid. (This will improve the affinity of the surface to the applied resin and allow more stable adhesion.)

③The activated liquid should be prepared immediately before application and used within 5 minutes.
New liquid should not be added to liquid already in the mixing dish, as this will adversely affect polymerization.

④Leftover Polymer powder should not be reused. Any powder remaining in the dish after the procedure is completed should not be returned to the jar.

1-1: Bonding brackets in the Direct Bonding System (DBS)

①**Bonding metal brackets to enamel**
Super-Bond forms a strong bond to stainless steel from which most orthodontic brackets and buccal tubes are made.

②**Bonding plastic brackets to enamel**
Super-Bond bonds to most plastics, such as polycarbonate from which plastic brackets are made, so no additional adhesive primers are necessary. (However, if composite resin brackets are not pre-silanated, they should be primed with Porcelain Liner M. This will allow Super-Bond to adhere to their inorganic filler.)

③**Bonding ceramic brackets to enamel**
Super-Bond bonds well to ceramic surfaces; however, it can be difficult to remove ceramic brackets because the materials are so stiff. Therefore, a shorter enamel etch time of 10 to 15 seconds is recommended (just one-third to a half the normal treatment time.) This will reduce the bond strength and make removal easier.

④**Bonding brackets to a composite resin veneered crown**
Once composite resin has polymerized into a crosslinked polymer, it is generally hard to bond to. The surface should be roughened with abrasive points. Then several coats of Monomer Liquid should be applied. Once this has been done, Super-Bond will achieve adhesive strength approximately equivalent to that to enamel.
Treating the surface with Porcelain Liner M will also help improve the bond by promoting adhesion to the composite's inorganic fillers.
The maxillary right lateral incisor was palatally malpositioned. It had been over-contoured with composite resin in order to bring the facial aspect in line with the other teeth. Prior to orthodontic treatment, the tooth was adjusted to its original shape and the bracket was bonded. This photograph shows the case four years, three months later, just before removing the appliance.

⑤**Bonding brackets to porcelain crowns**
Prior to bonding to a ceramic surface, the porcelain should be primed with Porcelain Liner M.
The right second premolar was restored with a ceramometal crown. After the ceramic surface was polished, Porcelain Liner M was applied (See the technical instructions for use) and the bracket cemented using Super-Bond. (Roughening the surface with abrasive points or diamond burs prior to application of the Porcelain Liner M will create stronger adhesion.)
This photograph was taken three years, ten months after the strap-up, just before removing the appliance.

1-2: Bonding bracket tubes to precious metal crowns

①The 46-year-old female patient demonstrated maxillary and mandibular protrusion. The maxillary left molars were restored with gold-silver-palladium crowns. Maxillary and mandibular first premolars were extracted.

②After polishing, washing and drying the metal crowns, V-PRIMER was applied. Using Super-Bond, a double buccal tube was bonded to the first molar, and a single buccal tube was bonded to the second molar.

③Four months after orthodontic treatment began, there were no problems. The tubes remained bonded to the metal crowns.

④A buccal view after completing orthodontic treatment.

6. Clinical applications

1-3: Direct bonding double buccal tubes for head gear (Maxillary extraoral anchorage appliance)

①At the first examination the 22-year old female showed a large maxillary protrusion (8.8 mm overjet).

②Normally, orthodontic bands on the upper first molars would have been necessary to withstand the strong traction force transferred through the face bow from the elastics attached to the head gear. In this case, however, because of Super-Bond's great strength, the double buccal tubes were bonded directly to the molars.

1-4: Cementing a lingual arch

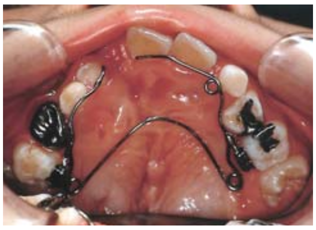
①An eight-year-old male patient presented with reversed occlusion including palatal malposition of the maxillary right incisor. Because the eruption of the first molars was incomplete, a ready-made lingual arch appliance was used. The buccal tubes were bonded to the second primary molars by DBS using Super-Bond.

②At four months. The reversed occlusion was improved using a 0.018 inch thick (0.46mm) auxiliary spring made of chrome-cobalt wire.

③Three years, one month. Because the patient had lost the primary second molars and the second premolars had begun to erupt, a lingual arch was bonded by DBS on the first molars for retention. The periodontal condition was good because no orthodontic bands had been used on the first molars.

1-5: Setting a W-type expansion appliance (Ref., Mogi M: Orthodontic treatments taking into consideration of periodontal tissues, Tokyo Society of Orthodontics,6,65-75,1996)

①A seven year, three month old male with right cleft lip, alveolus and palate. The treatment plan involved slow expansion with a W-type expansion appliance to correct the reversed occlusion and narrow dental arch. Because of the delayed eruption of the first molars, the appliance was bonded directly to the second primary molars with Super-Bond.

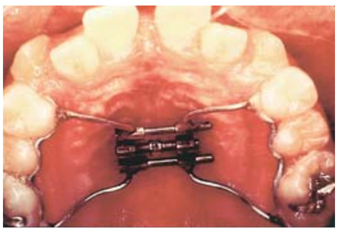


②Eight years, three months old. The dental arch was expanded and the reversed occlusion had improved. The left first molar began to erupt.

③Eleven-years, seven-months old. One year and five months after DBS multi-bracket treatment began, the periodontal condition was good, because orthodontic bands were not used on the first molars.

1-6: Setting a rapid expansion appliance

①An eleven-year-old male with a maxillary rapid expansion appliance. The appliance was made by soldering 1.2 mm orthodontic wires and then bonding the appliance to the three molars on each side.
Because orthodontic bands were not used, it was easy to set the appliance, without pain to the patient or damage either to the teeth or periodontal tissue.



②The expansion lasted more than 2 weeks. The wire fixation on the six teeth (Super-Bond applied by brush-dip technique) remained sound throughout expansion of the median palatine suture. For older patients, expansion of the palatal suture can be performed by extending the bonding wire to the canines.

1-7: Bonding a direct bonded retainer

■ A maxillary retainer

①Because of extensive crowding, the planned orthodontic treatment for this twenty-year-old female patient included extraction of the maxillary left lateral incisor and right first premolar.

②After active orthodontic treatment, a retainer from canine to canine was bonded directly to each lingual surface with Super-Bond. This photograph was taken three years, five months after cementing the appliance. Because the 0.7 mm stainless steal wire was directly bonded without using orthodontic bands, the retainer functioned well without affecting the occlusion.

■ A mandibular canine-to-canine retainer

①Because of mandibular prognathism with incisor crowding, orthodontic treatment for this nineteen-year-old female patient included extraction of the mandibular first premolars.

②After active orthodontic treatment, a retainer of 0.9 mm stainless steel wire, was bonded directly to the lingual surfaces of the anteriors (canine to canine) using Super-Bond. This picture was taken two years, four months after setting the retainer.

1-8: A direct bonded bridge with a resin pontic for congenitally missing teeth

(Ref., Mogi M, Miura F: Long term clinical appraisal of adhesion bridge with artificial resin teeth, AD, 5, 2, 95-102, 1987)

①At the first examination, the patient (a 14 1/2 year old male) showed edge-to-edge occlusion with congenitally missing maxillary lateral incisors and a posterior crossbite.

⑤The left lateral incisor 15 years, 3 months later. The tooth is in function, and the patient uses no special care when biting. Even after 15 years, there is no staining at the adhesive margins. Neither is there loosening nor discoloration, and the condition of the gingiva is satisfactory.

②Labial and lateral expansion of the dental arch was achieved using the multi-bracket, rapid expansion method for maxillary bone. The occlusion was improved and the space was concentrated in the area of maxillary lateral incisors. After active orthodontic treatment, resin teeth were bonded directly to the adjacent teeth with Super-Bond. Following the instructions, the abutment teeth were cleaned, polished, conditioned, washed with water, and dried. During the bonding procedure the surfaces were kept free from moisture contamination.
To increase the area available for bonding, the dentist treated not only the proximal surfaces, but also one-quarter of the labial and lingual surfaces.

③Resin denture teeth were selected that matched the color of the proximal teeth. They were ground to the proper size and polished.
The surfaces of the denture teeth that would be bonded were roughened with abrasive points. Using disks, some vertical and horizontal grooves were cut.

④Super-Bond (with less Polymer powder than usual) was applied around the contact points using the brush-drip technique, and the resin teeth were bonded in place. Once the adhesive materials began to harden and the resin teeth were secured, adhesive with more Polymer was added to the labial, lingual and incisal areas. The photo above shows the left lateral incisor. The right lateral incisor was added similarly. When Super-Bond is mixed using Clear Polymer powder, the cured film is transparent and scarcely visible when moist with saliva. Consequently esthetics is not compromised, even if the cement extends onto the labial or incisal surface.

2. Direct fixation of mobile teeth and the direct bonded bridge

If a tooth has slight mobility, it can often be splinted directly to the adjacent teeth with Super-Bond (direct resin fixation). After preparing the enamel, apply Super-Bond to the proximal surfaces using the brush-dip technique.
Though extremely easy compared with traditional techniques for splinting, direct Super-Bond fixation works surprisingly well, because of the resin's flexibility and elasticity. It is also quite esthetic.
It is possible to make a prosthesis for replacement of 1 or 2 teeth by bonding a resin tooth (or extracted tooth) directly into the edentulous space (The resin direct bonded bridge). If the adjacent teeth are virgin, and therefore the dentist would like to avoid cutting abutment preparations, this technique should be one of the treatment options considered. It is easy and completely reversible because it causes no damage to the remaining teeth.
This technique was initially thought to be appropriate only for temporary restoration. However, many clinical cases have shown that these "bridges" can last several years, and some cases have been functioning for more than 10 years. (Refer to the clinical cases 1-8, 2-4)

Clinical hints

①If a tooth has hypermobility, supplement the Super-Bond with reinforcement such as an adhesive splint or an adhesive bridge (described later).
②Treat the proximal surface with the Red Activator. Wash and dry. Take care that the surface does not become contaminated with breath, saliva, blood, etc.
③The resin tooth should be modified in order to enlarge the surfaces to be bonded.
④Roughen the surfaces of the resin tooth that will be bonded using abrasive points, or use disks to cut some vertical and horizontal grooves.
If the resin tooth contains inorganic fillers, the bond will be enhanced by treatment with Porcelain Liner M.
⑤The resin tooth should be bonded using the brush-dip technique, utilizing the Clear Polymer powder for esthetics. Do not move the bonded tooth before the cement has cured completely.

2-1: Direct fixation of a mobile tooth

①After treating the proximal surfaces with Red Activator, bond the mobile teeth together with Super-Bond using the brush-dip technique. The Clear Polymer powder is normally used to be inconspicuous. (Feb.1994)

②Labial view at 1 month.

③Lingual view at 1 month.

④The splint continues to function normally after 3 years, 7 months. (Sept.1997)

⑤Radiograph after 3 years, 7 months.

2-2: Maxillary direct bonded bridge with resin teeth

①Though the patient is missing the lateral incisor, the adjacent teeth are perfectly healthy. Therefore, the dentist decided to avoid traditional crown preparations and instead used Super-Bond to create a bridge by bonding a resin tooth in the gap.

②A resin tooth is selected for proper shade match. The tooth is reformed and polished. Here, the tooth is tried in. For the best bond possible, the denture tooth should have extensive contact with the abutments (Not point contact.)

③The surfaces of the resin tooth that will be bonded are roughened with abrasive points. Horizontal and vertical grooves are cut into the tooth using disks in order to enlarge the area for stable adhesion. Immediately before bonding, Super-Bond's activated liquid should be applied. (If the denture tooth is a heavily filled resin composite, the adhesive surface should be treated with Porcelain Liner M before the activated liquid is applied.)

④The abutment teeth are cleaned. The surfaces to be bonded are treated with Red Activator, washed and dried completely. These surfaces must remain uncontaminated by saliva, etc.

⑤Apply Super-Bond's activated liquid to the abutments' proximal surfaces.

⑥Apply Super-Bond (using Clear Polymer powder) to the adjacent teeth using the brush-dip technique. Then quickly set the resin tooth in position.

⑦Add Super-Bond to the proximal surface. Keep the tooth immobile until the adhesive resin cures.

⑧The completed direct-bonded bridge. Once wet with saliva, Super-Bond is transparent, so the esthetics is good.

⑨At 3 years, there has been no debonding, no discoloration and the bridge continues to function well.

2-3: Mandibular incisor direct-bonded bridge with resin teeth

①This patient presented with an old anterior 4-unit bridge, and requested that something be done to improve the esthetics.

②When the bridge was removed and the abutment teeth cleaned, it was found that both abutments were caries-free and that their enamel was intact.

③A bridge was created by bonding two resin teeth to the abutments using Super-Bond and the brush-dip technique.

④3 years, 3 months later. Although some staining can be seen in the proximal areas, the bridge is functioning well.

2-4: Direct bonded bridge using an extracted tooth

①In 1984, a mandibular lateral incisor was extracted and used for restoration. The root was amputated and the canal sealed with resin composite. The tooth was then bonded directly to the proximal teeth with Super-Bond using the brush-dip technique. Though the restoration was thought to be temporary, this bridge has been functioning satisfactorily for ten years.

6. Clinical applications

3. Adhesive splint technique

Super-Bond can be used in a number of ways to stabilize mobile teeth in addition to the direct bonding technique described in 2. Wire, mesh plates, or cast metal may be combined with Super-Bond to provide stronger fixation.

Clinical hints

①Mobile teeth should be temporarily stabilized on the labial surface in order to prevent movement during impression-taking or cementation.
②Pink or Ivory Opaque Polymer powder is recommended to prevent show-through of a dark metal splint.
③The splint should not be moved during polymerization.

3-1: A lingual splint using cast metal

①A female patient (54 years old) suffered from severe periodontal disease. If the anteriors were to be saved they had to be immobilized with a splint. (February, 1979)

②The teeth were temporarily stabilized with a wire on the labial to prevent movement during impression procedures and cementation.

③An X-ray examination before treatment.

④A lingual splint was made of gold-platinum alloy. At that time, the casting was heat-treated to allow formation of a reactive oxide layer. Recent introduction of V-PRIMER has made treatment of the metal surface easier. (May, 1980)

⑤At 14 years, 3 months. Despite severe resorption of alveolar bone, the anteriors remained stable. (August, 1994)

⑥At 15 years, 5 months. A lingual view of the splint. (October, 1995)

⑦At 16 years, 8 months. Though the mandibular teeth showed gingival recession, they remained stable without complications. (January, 1997)

⑧After 17 years, 2 months, the lingual plate on the lower right canine debonded. (July, 1997)

⑨However, by this time the teeth and bone had become so stable, that it was decide to simply section the loose lingual wing and allow the canine to function unsplinted.

⑩A lingual view after removal of the wing. Though bonded for seventeen years with Super-Bond, no secondary caries had formed around the adhesive surface.

⑪At 17 years, 3 months. A facial view of the anteriors. (August, 1997)

3-2: An adhesive splint with mesh wings

①A mesh plate was pressed onto the working model to quickly create an adhesive splint.

②The splint with mesh plate was bonded to the lingual tooth surfaces using Super-Bond.
The splint is thin and flexible enough to accommodate physiologic tooth movement.

4. Indirect adhesive inlay, onlay, crown-and-bridge restorations

Because Super-Bond resists degradation in saliva, it creates an effective marginal seal between tooth and restoration. It not only bonds the restoration securely to the preparation to resist dislodging but also prevents leakage and secondary caries.
Once the components are mixed, Super-Bond should be used as soon as possible, while the mixture is still fluid. If the material begins to thicken due to polymerization, the restoration may not seat completely.

Clinical hints

① Proper pretreatment of the surface to be bonded is essential. The pretreatment varies according to the material being bonded (metal, porcelain, resin).
② If the preparation includes both enamel and dentin, it should be treated with the Green Activator. Use the Red Activator if only enamel is involved.
③ Polymer powder should be chosen according to the esthetics of the specific case (masking metal, matching a color, minimizing marginal lines, etc.). When using the opaque powder, the working time will be longer and excess resin will be easier to see during clean up.
④ The cement should be used while the mixture is still fluid (before threading starts). The restoration should be held immobile while adhesive cement cures.
⑤ Excess cement should be removed completely.

4-1: Bonding partial onlay crowns with Super-Bond

①The patient complained of temporomandibular joint pain. Examination revealed occlusal caries on the molars of both maxillary quadrants. The molars required restoration of functional occlusal form. (July, 1982)

②Tooth preparation was limited to caries removal. No attempt was made to create retention form. Metal onlays for occlusal reconstruction were fabricated. The castings were heat-treated to create a reactive oxide layer. (Recent introduction of V-PRIMER has eliminated the need to pre-oxidize noble alloys.)

③The onlays were bonded to the molars with Super-Bond.

④A facial view after thirteen years. During this period, several onlays have dislodged, but no carious lesions have been discovered. When they debonded, the onlays were simply re-cemented.

4-2: Porcelain jacket crowns bonded with Super-Bond

①A patient required four esthetic ceramic crowns for the upper incisors.

②Because the treatment plan involved bonding the crowns with Super-Bond, they were designed thinner than normal (1 mm labial thickness and 0.6 mm lingual thickness.) Once cemented, crown and prep would form a single unified structure that would reinforce the fragile porcelain.

③The interior surfaces of the crowns were treated with the Red Activator to remove contaminants that might impair the bond. The crowns were then rinsed and dried. The interiors were primed with Porcelain Liner M. After the application of Porcelain Liner M, the crowns were heated using a blow dryer to improve bond durability.

④The preparations were treated with Super-Bond's Green Activator, then rinsed thoroughly and air-dried.

⑤Super-Bond was mixed using the Clear Polymer powder and applied to the ceramic crowns. The crowns were then immediately seated, and the excess resin cement wiped off as soon as possible.

⑥The case immediately after cementation shows the cosmetic effect.

4-3: A telescopic partial denture retained by copings bonded with Super-Bond

①The completed telescopic partial denture at the laboratory. The facial surfaces were coated with Super-Bond (Opaque Ivory Polymer powder) and veneered with "Meta-Color" resin composite.

②The abutment preparations were treated with the Green Activator, then rinsed thoroughly and air-dried.

③After the inner surfaces of the overlay copings had been sandblasted and tin-plated, they were cemented with Super-Bond. (Recently, V-PRIMER has made pretreatment of noble metal simpler and easier by eliminating the need to tin-plate.)

④The completed telescopic partial denture immediately after insertion.

⑤After eight years, the prosthesis remains asymptomatic.

4-4: An interlocking bridge bonded with Super-Bond

①A sixty-nine-year-old female patient required replacement of an extensive maxillary bridge. Due to the number of teeth being crowned and the length of the edentulous span (from cuspid to third molar), it was thought that if the bridge were luted with a traditional inorganic cement, deformation during mastication might cause partial dislodging.

②Since the prognosis of the right third molar was questionable, a precision attachment was placed on the distal surface of the right cuspid, and the span from the right first premolar to the third molar was fabricated as a fixed/removable segment. The surfaces to be bonded were tin-plated. (The recent introduction of V-PRIMER has made this pretreatment simple and easy.)

③The bridge was bonded with Super-Bond (Opaque Pink Polymer powder). The color of the resin flash contrasted with the prosthesis, facilitating the clean-up.

④Just after bonding. (August, 1986)

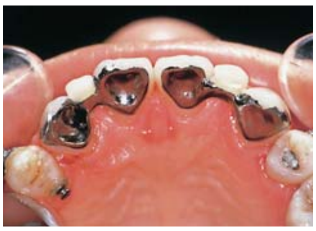
⑤Margins of the upper central incisors.

⑥The case after eight years, eight months remains asymptomatic. (April, 1995)
Because the segmented bridge was bonded to the abutments, it created a single unified structure.

⑦The porcelain veneered crowns featured ceramic supragingival margins for esthetics. At eight years, eight months, the anterior teeth showed severe gingival recession. However, the Super-Bond had not discolored, and there was no evidence of secondary caries. (The bridge has been in the mouth now for eleven years, one month, without any problems.)

4-5: An anterior adhesive bridge bonded with Super-Bond

①After minor tooth movement, adhesive bridges running from cuspid to cuspid were planned to replace missing lateral incisors. No retention form was prepared on the abutments, but incisal rests were included to provide vertical and lateral stops during cementation.



②A lingual view. The incisal rests were cut off after bonding. (July, 1983)

③At 12 years and 6 months, the adhesive bridges remain asymptomatic.

4-6: An anterior interlocking adhesive bridge using Super-Bond

①The patient was unhappy with the existing removable prosthesis, and requested an esthetic replacement for the missing central incisor.

②An interlocking adhesive bridge was planned. To improve the long-term durability, additional retention form such as cingulum rests, proximal grooves, ledges, or pins should be prepared in the enamel to relieve some of the masticatory pressure from the cement film.

③The adhesive bridge immediately after cementation with Super-Bond.

④After ten years the adhesive bridges remain secure.

4-7: A posterior interlocking adhesive bridge using Super-Bond

①The patient was missing a lower first molar.

②An Au-Ag-Pd adhesive bridge was fabricated. During tooth preparation the dentist carefully avoided reducing the cusps in order to preserve the natural occlusal relationship. The retentive wings were sandblasted and treated with V-PRIMER. (August, 1987)

③The bridge was bonded with Super-Bond C&B.

④After nine years the bridge continues to function, demonstrating the long-term durability of Super-Bond to precious metal prepared with V-PRIMER.

4-8: A anterior adhesive bridge using mesh plate and Super-Bond

①Severe periodontal disease made preservation of the maxillary incisor impossible.

②After the extraction, a lingual mesh plate was bonded using Super-Bond to create a bridge/splint.

③The root of the extracted tooth was amputated, and the crown was bonded directly to the mesh plate.

④The facial view of the immediate adhesive bridge.

5. Repair of fractured prostheses

If the facing of a veneered crown or bridge fractures or debonds, it is often possible to repair the crown intraorally without removing the prosthesis. Shown here are various cases that illustrate the appropriate pre-treatment and bonding procedures using Super-Bond.

Clinical hints

①The factors that caused the original fracture must be identified and eliminated or some reinforcement must be included in the repair to prevent recurrence.
②The fractured surface should be cleaned, roughened and then primed with a conditioner appropriate for each material.
③The Polymer type should be selected to permit an esthetic restoration.
④If the fractured fragment is usable, it should be bonded in the correct position with Super-Bond.
⑤If the fractured fragment has been lost, a thin coat of Super-Bond should be applied to the fractured surface and cured. Then resin composite should be applied over the Super-Bond layer.

5-1: Repairing a fractured resin-veneered pontic

①A maxillary resin veneered bridge extending from the right first premolar to the left first premolar fractured. The patient brought the fragment to the office so it could be rebonded.

②The opaque remained on the fractured surface of the fragment. In order to remove contaminants that might affect adhesion, the fragment was cleaned using the Red Activator. After thoroughly rinsing and drying, Porcelain Liner M was applied to the fractured surface.

③In the oral cavity, a fresh metal surface was exposed using a diamond bur. The entire fractured surface was cleaned with the Red Activator, then rinsed and dried. V-PRIMER was applied to exposed metal, taking great care not allow it to touch the resin surface.

④Porcelain Liner M was applied to the resin area of the fractured surface.

⑤Super-Bond was quickly brushed onto the treated surfaces of both pontic and fragment using Clear Polymer powder in the brush-dip technique. (If the practitioner is not familiar with the brush-dip technique, he can use the bulk-mix technique. The Polymer/Liquid ratio should be reduced to lower viscosity.)

⑥The fragment was quickly placed in the proper position and held while the Super-Bond cured. Before the curing was completed, excess resin was removed. During this clean-up, the fragment was firmly held in placed to avoid movement.

⑦The final repair, after adjusting the occlusion and polishing.

⑧One year later, the repaired bridge continues to functioned well.

5-2: Repair of fractured porcelain veneered crowns

①The ceramometal bridge suffered numerous fractures, and the ceramic fragments had been lost.

②Before repair, the fractured surfaces of both porcelain and metal were slightly cut, and the form modified using a diamond bur.

③V-PRIMER was applied to the exposed metal, and Porcelain Liner M was applied to the fractured porcelain surfaces. (Care was taken not to get any V-PRIMER on the porcelain surfaces.)

④Super-Bond was applied to the fractured surfaces. To allow transparency, the Clear Polymer powder was used when coating the porcelain surfaces. Opaque Ivory Polymer powder was used when coating the metal. This would mask the dark metal color and prevent show-through.

⑤After the adhesive had cured, Activated Liquid was applied over the Super-Bond layer, and the veneer was repaired using resin composite.

⑥After light-curing, the restoration was completed by adjusting the occlusion and polishing.

⑦Four years after repair, the teeth still functioned beautifully without further fractures.

5-3: Repairing fractured ceramometal crowns

①The patient presented with porcelain fractures on the maxillary left central and lateral crowns.
The central had fractured due to impact. Most of the fracture occurred within the porcelain, but there was a small metal exposure. The lateral, which had fractured due to traumatic occlusion, occurred entirely within the porcelain.

②The patient brought the ceramic fragment from the central incisor. Though the fragment fitted well, there were some defects.

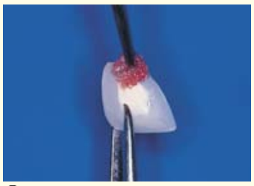
③Porcelain Liner M was applied to the fractured porcelain of both the fragment and the crown. The fragment was then bonded in position using Super-Bond (Clear Polymer powder). Since the amount of exposed metal was so small, special metal treatment was omitted.

④After the fragment was rebonded, the defect was conditioned with Porcelain Liner M and repaired with resin composite.

⑤The repaired bridge in left lateral excursion. Because the repaired area of the maxillary lateral coincided with the morphological form of the mandibular lateral, it was presumed that the fracture was caused by incisal interference. In this case, it would have been wise to modify the form of the fractured teeth, rather than simply repair the fracture.

Step-by-step clinical procedure: Repair of a fractured porcelain veneered crown

①The ceramometal crown has fractured, exposing both porcelain and metal surfaces. If the fractured fragment fits the defect, it can be used to repair the crown. But the metal and porcelain surfaces should be properly pre-treated before bonding.



②The fractured surfaces of the fragment should be cleaned with the Red Activator. This will remove contaminants that might interfere with bonding. After applying the Red Activator, the fragment is rinsed and dried. Once this has been done, care must be taken not to contaminate the surfaces.

③One coat of Porcelain Liner M is applied to the fragment's fractured surfaces.

④The contaminated metal is lightly abraded with a diamond point. This will remove any remaining porcelain fragments, expose fresh metal, and increase the surface area by roughening it.

⑤The fractured surface should be conditioned with the Red Activator, followed by rinsing and drying.

⑥V-PRIMER is applied only to the exposed metal, taking great care not to get primer onto the porcelain surface.

⑦Porcelain Liner M is applied to the fractured porcelain surface.

⑧If insufficient opaque remains on the fragment to mask the dark metal, the metal should be opaqued by applying a thin later of Super-Bond using the Opaque Ivory Polymer powder. Then the fragment should be bonded in the correct position with Super-Bond mixed using the Clear Polymer powder. The fragment should be held in position until the adhesive cures. The operator can use either the "brush-dip technique" or the "bulk-mix technique". However, in either case, the adhesive should be applied and the fragment positioned quickly, before the cement becomes viscous.
As much of the excess resin as possible should be removed before it hardens.

⑨After the Super-Bond has cured, all remaining excess resin should be removed. The occlusion should be equilibrated to reduce stress on the fractured area in centric occlusion, and in protrusive and lateral excursions.

⑩The fracture line as well as any incisal/occlusal areas that have been adjusted during equilibration, should be polished with silicon points. (Inadequately polished areas may become starting points for new fractures.)

⑪The fracture line and equilibrated areas should also be polished using a rubber cup and diamond pastes.

⑫A postoperative view of the completed repair. If the fracture line is still visible, a tiny groove should be cut along the fracture line using a round bur. After conditioning with Porcelain Liner M, this groove should be filled with resin composite.

6. Core buildup

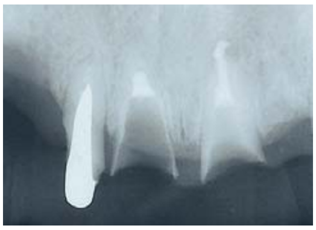
Because it bonds to both dentin and metal, Super-Bond is extremely effective for core buildups.
When a cast metal post-and-core is bonded to the tooth with Super-Bond, the tooth and prosthesis form a single unified structure. So the dual-risks of the dislodgment and root fracture both decrease dramatically.
The adhesive amalgam core technique has been clinically evaluated and found to be extremely useful when restoring still-vital teeth and broken down molars with 2 or 3 root canals.

Clinical hints

①Caries-affected tissue should be removed carefully to preserve as much sound tooth structure as possible. In the case of vital teeth, vitality tests should be properly performed. Great care should be taken not to injure or expose the pulp. If necessary, pulp-protective treatment should be used.
②The post preparation should be as long as possible.
③After surface treatment of the post preparation, the root canal should be dried. This will take some care because of the cavity's long narrow shape.
④Super-Bond should be applied while it is still fluid, taking care to spread it on all surfaces of the root canal.

6-1: Adhesion of a cast metal post-and-core


①When the unbonded posts in these maxillary centrals dislodged, extensive secondary caries were discovered within the canals. After caries removal a funnel-shaped cavity was prepared in what remained of the root.


②It would be impossible to retain posts in these severely tapered preparations using traditional technique and a conventional inorganic cement.


③Cast metal posts-and-cores were fabricated and heat-treated in order to form a reactive oxide layer. Recently, use of V-PRIMER makes pretreatment of precious metal surfaces much easier.


④The castings were bonded in place using Super-Bond. (February, 1984)


⑤The final prosthesis, one year, nine months after the cast metal cores were cemented.


⑥This radiograph taken ten years, eight months after the initial treatment, shows that the teeth remain secure without root fracture.

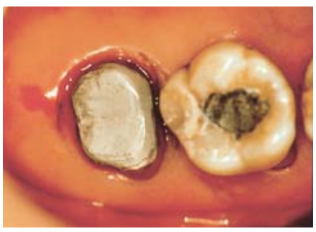
6-2: Adhesive amalgam core buildup using prefabricated posts


①After removing the root canal filling and carious tissue, several prefabricated posts were inserted to check the fit. Because of the divergent direction of the posts, they would provide strong mechanical retention.


②X-ray examination showing the prefabricated posts at try-in. Though the coronal preparations are large, the root structure remains strong enough to support the prosthesis. This situation is frequently seen in molars.


③A matrix band was lubricated with a releasing agent, and applied to the tooth. Then the dentin surface was conditioned with the Green Activator. A thin Super-Bond mixture was prepared using less Polymer than usual. The cement was applied first to the post cavities and then to prefabricated posts. The posts were immediately inserted into the root preparations.


④Before the Super-Bond had begun to cure, premixed amalgam was condensed into the preparation.


⑤After the amalgam had set, the core was prepared as usual. (January, 1988)

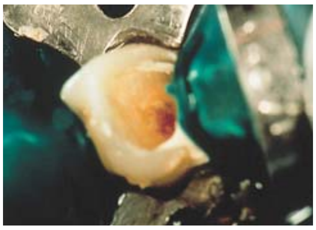

⑥An X-ray examination nine years, seven months later. (September, 1997)


⑦Buccal view after nine years, seven months. The adhesive amalgam and bonded posts were functioning well after more than nine years. (September, 1997)

6-3: Adhesive amalgam core for a vital tooth

①The patient presented complaining of pain. The source was traced to deep caries in the mandibular left first premolar.

②Though the initial X-ray examination revealed that the caries had reached the pulp, the tooth responded normally to vitality tests. Therefore, a treatment plan was developed to avoid endodontic therapy.



③The carious tissue was removed without anesthesia. Despite taking great care, pulpal exposure was unavoidable. The exposure was covered with a calcium hydroxide paste and temporized. After approximately two months, the formation of a dentin bridge was confirmed.

④The cavity was restored with adhesive amalgam using Super-Bond as described in case 6-2. Because esthetics was extremely important for this patient, the tooth was prepared for an all-ceramic crown. The amalgam was firmly bonded to the dentin, so crown preparation could proceed without fear of dislodging the core or damaging the marginal seal. (April, 1988)

⑤The all-ceramic crown was cemented using Porcelain Liner M and Super-Bond. At one year, 6 months, the tooth remained secure and asymptomatic, without any pulpal complications.

⑥X-ray examination after three years. The pulp remains healthy because of the seal created by the Super-Bond. The adhesive amalgam restoration has proved extremely helpful in preserving vital pulp during core buildup.

7. Conservation of vertically fractured teeth

In the past, teeth suffering vertical fractures were considered virtually impossible to save. Today, fractured teeth are routinely preserved using adhesive Super-Bond. Numerous clinical cases surviving more than ten years have been documented, clearly confirming that Super-Bond allows long-term conservation of fractured teeth. This long record has allowed establishment of definite clinical procedures.

Clinical Hints

①If the tooth has fractured without dislocation of the segments, the "Intraoral Adhesive Method" is preferable.

②After the adhesive repair, flash from the fracture lines and periodontal granulation tissue should be removed. When a fracture line is located at an area that is unreachable with instruments, the "Intraoral Adhesive Method" is not indicated.

③If a recent fracture involves dislocated segments but no bone resorption, the "Adhesion Method with Reimplantation" is indicated.

④If an extended period has passed since the fracture, and the alveolar bone has resorbed at the fracture site, "Adhesion with Rotating Reimplantation" should be selected. In this technique the extracted tooth is rotated before replantation in the socket.

⑤A metal core should be placed after the biologic attachment between a reimplanted tooth and periodontal tissue has been confirmed.

7-1: Intraoral adhesive repair of a fractured anterior tooth

①The root of a right upper central incisor was fractured twelve years, ten months after restoration with a Richmond crown. Traditionally this tooth would have been doomed to extraction; however, the author decided to save the tooth by rebonding the restoration to the fractured root using an adhesive cement. (Sep. 1982)

②The restoration was removed and heat-treated to oxidize the metal. The restoration was then painted with Super-Bond C&B and recemented in the fractured root. (Recently, V-Primer was introduced to make this pretreatment simple and easy.)

③Because the prognosis was good, aproximately 3 years after recementation, the discolored porcelain facing was removed intraorally and repaired with resin composite. (Jun. 1985)

④Ten and a half years after the recementation. Because clinical adhesion for this long a period had never been directly observed, the Richmond crown was removed in order to check the durability of the adhesion. A black discoloration was discovered on part of the resin surface. It may have been caused by leakage between the restoration and the resin. (Mar. 1993)

⑤The resin on the root was removed. The bond to the fractured area was good, even though more than ten years had passed. The fracture line did not show any signs of leakage, discoloration or secondary caries.

⑥The root appeared to be well-preserved, so a new post together with those for other three teeth was fabricated and cemented. (Sep. 1993)

⑦A facial view of the ceramometal crowns. Fourteen years, six months after the original repair of the fractured root, the tooth continues to function asymptomatically.(Mar. 1997)

⑧A radiograph taken twelve years, nine months after the fracture shows no evidence of problems with periodontal tissue or bone. (June. 1995)

7-2: Intraoral adhesive repair of a fractured posterior tooth

①The patient presented complaining of pain when occluding on a maxillary posterior bridge. The bridge had been placed fourteen years earlier (1971). A fracture line could be seen on the exposed root surface of the left upper first premolar and an abscess had formed. (Apr. 1985)

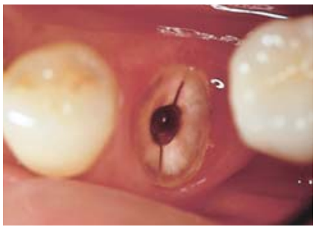
②The restoration was removed and the deep caries excavated. This left a funnel-shaped cavity with little intact dentin. Four fracture lines could be seen, but there was no full dislocation of the fragments.

③A metal core was cemented with Super-Bond. Two weeks after cementation, the excess resin was curetted. Bone resorption was detected around three sides of the root, so hydroxyapatite was used to fill the bony defect. (Jun. 1985)

④Eleven years, two months after the repair the tooth remained asymptomatic. Probing showed that periodontal pockets around the premolar were just 2 mm. (Aug. 1996)

⑤An X-ray examination at the same recall appointment showed good alveolar support. Even though it has been functioning as a bridge abutment under severe conditions, the repaired tooth has an excellent prognoisis.

7-3: Adhesive repair of a fractured tooth with extraction and reimplantation



①Because it was suspected that one of the bridge abutments had fractured, the prosthesis was removed and a bucco-lingual fracture was discovered.

②The fractured tooth was carefully extracted making every effort not to damage the periodontal ligament. While the segments were held with forceps, the periodontal granulation tissue and carious tissue were removed, and the fractured surface was cleaned. The fractured surfaces were conditioned with the Green Activator and bonded with Super-Bond.

③After curing, the tooth was held with forceps as the excess resin was removed. Then the bonded tooth was reimplanted. (Dec. 1993)

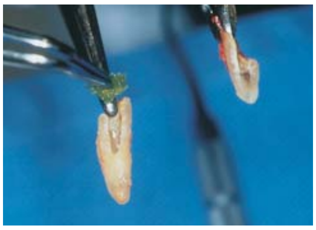
④Examination after three months, shows the fracture line filled with resin. This "Extraoral Method" produces a thinner resin layer than does the "Intraoral Method".

⑤An X-ray examination of the reimplanted bridge abutment after four years showed no evidence of problems.

7-4: Adhesive repair of a fractured tooth with rotation and reimplantation

①The left upper lateral incisor had fractured in the labial and lingual direction. The segments had separated and there was substantial bone resorption apposing the fracture.

②After extraction of the fractured segments, granulation tissue, caries and contaminated cementum were removed. The segments were held in forceps during these procedures.



③After confirming that the original root shape could be reconstructed using the fractured segments, only the fractured surfaces were dried and conditioned using the Green Activator.
The surfaces to be bonded were washed with physiological saline solution and dried. The periodontal ligament should not be allowed to dry during the procedure. (An air syringe with thin nozzle is very effective for controlled drying.)

④Super-Bond was applied to the fractured surfaces, and the segments bonded together and held with forceps. A Gutta Percha point should be inserted into the root canal during this procedure to facilitate the subsequent post preparation.

⑤As the bonded tooth was held with forceps, excess resin was removed. During this procedure the root was rinsed with physiological saline solution.

⑥When the tooth was reimplanted, it was rotated 90 degrees. In this way the intact periodontal ligament on the tooth would face the damaged tissue in the alveolus. (Jun. 1995) Generally, two weeks is sufficient for fixation.

⑦The preparation for a metal core was created one month after the rotated reimplantation. Notice that the fracture line is now at right angles to its direction in the first photograph. (Jul. 1995)

⑧The metal core was bonded using Super-Bond and V-PRIMER. An X-ray image one year after cementing the crown.

⑨A facial view two years after the replantation. (Jul. 1997)

⑩The X-ray examination at the two-year recall appointment reveals excellent bone structure. The tooth remains asymptomatic.

8. Conservation of teeth with root perforations

When removing caries from root preparations, inadvertent perforation may be unavoidable. Super-Bond has been used with good clinical success to repair and seal these perforations.

Clinical hints

①If the perforation is small, simply cementing a cast metal post/core with Super-Bond may suffice to repair it.
②If the perforation is large, repair using the "Adhesive Amalgam Method" is indicated.
③When a perforation is large and involves bone resorption, the perforation should be closed using the "Adhesive Amalgam Method". Then the flash of resin and amalgam and the periodontal granulation tissue should be curetted.
④When a perforation is extremely large or curettage difficult, the tooth may be extracted, repaired extraorally and replanted.

8-1: Repairing a perforation with post cementation

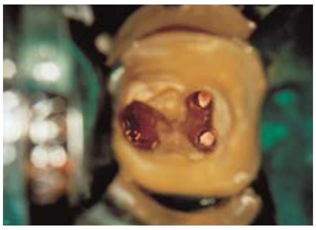

①During post preparation of the second mandibular molar, the instrument perforated slightly through the end of post cavity, causing minimal bleeding. (Dec. 1987)

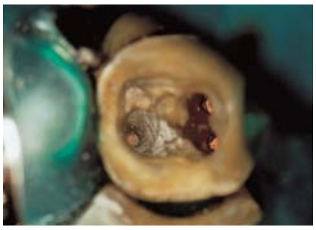

②The small perforation was detected by inserting cotton. If this perforation were left untreated, and the core cemented using a traditional inorganic cement, exposure to tissue fluid would degrade the luting agent, leading to leakage and chronic inflammation.


③The radiograph after post preparation. A small perforation like this can easily be sealed by cementing the metal core with Super-Bond.


④An X-ray image eight years, eight months after the bridge was cemented. There is no evidence of resorption or reports of discomfort. (Aug. 1996)

8-2: Repairing a perforation with adhesive amalgam (Intraoral Adhesion Method)


①A perforation of approximately 2 mm diameter was identified in the furcation area of the distal root of the mandibular right first molar.


②After completing endodontic therapy, the perforation was sealed using the adhesive amalgam technique. Amalgam can be seen on the distal lateral wall. (Jan. 1989)


③Radiograph taken immediately after repairing the perforation. Though the perforation was relatively large, the surrounding bone was sound and none of amalgam had protruded through the opening. Therefore no curretage was performed.


④A post-operative radiograph taken seven years, seven months later shows how effective the treatment was in sealing perforation.

8-3: Repairing a perforation with adhesive amalgam (Extraoral Adhesion Method with Reimplantation)


①Severe resorption around the molars had doomed the posterior bridge running from the first premolar to the second molar. Radiographic examination revealed a large perforation of the first premolar apical to the prefabricated post. There was a radiolucency in the supporting bone.


②The premolar was extracted minimizing damage to the periodontal ligament. The perforation was filled extraorally with adhesive amalgam.


③After repairing the perforation, the tooth was reimplanted in its original position.


④Ten months after reimplantation, a cast metal core was cemented in the premolar. A new cast core was also cemented in the second premolar. Implants replaced the first and second molars. (Feb. 1996)


⑤The splinted crowns from the first premolar to the second molar implant. (Mar. 1996)


⑥A radiograph taken 25 months after repairing the perforation, shows good alveolar support and confirms healing of the defect adjacent to the perforation site. The gingiva appeared healthy. (Sep. 1997)

9. Protection of prepared vital dentin

The importance of protecting the vulnerable pulp after vital dentin has been cut is now generally recognized.
One highly effective way to accomplish this is to seal the preparation with Super-Bond. The hybrid layer created where the adhesive penetrates the dentin provides effective protection in a wide range of applications.

Clinical hints

①Only carious dentin should be removed during preparation to preserve as much intact dentin as possible.
②If removal of deep caries threatens to expose the pulp, stop preparation before exposure, place an indirect pulp cap using antibiotic materials or calcium-hydroxide and temporize.
③Before sealing the dentin with Super-Bond, vitality tests should be conducted to check the vitality of the pulp.

9-1: Caries treatment using adhesion

①Dentin caries. Carious dentin should be removed, preserving as much healthy dentin as possible.

②Carious dentin was carefully removed using an excavator and Caries Detector. When deep caries cannot be entirely removed without endangering the pulp, as much as possible may be removed and a three-component antibiotic agent placed as proposed by Iwaku, et al and wait for healing.

③The surface was conditioned with the Green Activator.

④Super-Bond was applied to the cavity floor, sealing the dentin surface with a hybrid layer.
Notice that the purpose of Super-Bond is not to retain the restoration. Everything through this step can be thought of as "caries treatment". The balance (steps 5-8) describe the restorative procedures.

⑤The cavity was temporarily filled with a water-setting cement which would not affect subsequent resin adhesion.

⑥After completion of the caries treatment, restoration should be planned, and the cavity be prepared.

⑦A resin composite inlay was selected for this case. The indirect inlay was fabricated as usual.

⑧The surfaces to be bonded were treated according to the Super-Bond instructions and the inlay was cemented with Super-Bond.

9-2: Temporary restoration of an onlay preparation using Super-Bond (Radiopaque Polymer powder)

①An old inlay was being replaced. During elimination of secondary caries, a small pin-point exposure occurred.

②The exposed pulp was capped with a pulp-capping material that included hydroxyapatite and antibiotic agents.

③The cavity was temporarily filled with Super-Bond using Radiopaque Polymer powder.
The Super-Bond created a hybrid layer seal, to protect both pulp and dentin.

④An X-ray image of the temporarily-filled tooth. Super-Bond with Radiopaque Polymer powder is clearly seen on this radiograph because of its radiopacity.

⑤Both Super-Bond and the capping material were removed ten months later. Formation of a secondary dentin bridge was confirmed. A metal onlay was cemented with Super-Bond. This is a radiograph taken at the 1-year recall appointment.

9-3: Dentin protection of an inlay cavity

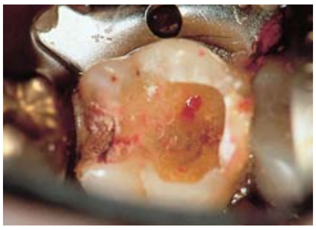
①A patient presented because of food impaction at the upper first molar. The tooth was not painful, and reacted normally to an electric pulp vitality test. The radiograph showed caries on the mesial proximal and occlusal surfaces.

②A Class II inlay preparation was made under the local anesthesia. Although the occlusal cavity was prepared with a dovetail design for retention and preventive extension, the cavity floor was determined primarily by caries removal. Although some retention form was created, as much sound dentin as possible was left untouched.

③The dentin surface of the cavity was conditioned with the Green Activator for ten seconds and coated with Super-Bond (Radiopaque) using the brush-dip technique. This adhesive lining would eliminate the discomfort normally associated with the temporary filling.

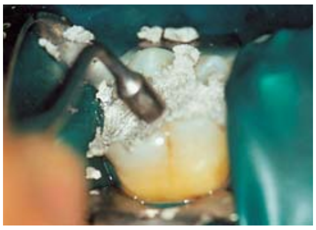
④A 20K gold inlay was bonded with Super-Bond. Because of the excellent seal created by the Super-Bond liner, the patient experienced no sensitivity as the temporary filling was removed and the surface conditioned for bonding.
During the three years since cementation, the tooth has caused no discomfort at all.

9-4: Dentin protection using an adhesive amalgam base



①The patient presented complaining of occlusal pain. Examination revealed secondary caries at the distal of a metal inlay in the right lower first molar.
Carious tissue was removed without anesthesia, aided by Caries Detector. Removal of deep caries resulted in pulpal exposure.

②The exposed pulp was directly capped with Carvital. Four months later, the Carvital was removed and the formation of a dentin bridge confirmed. Observation and electric pulp test confirmed that the pulp was vital.



③The cavity was filled with adhesive amalgam. (Apr. 1988)

④After the amalgam had set, a core was prepared for an onlay. Amalgam does not shrink during setting, so it does not create a contraction gap. As a result, bonded amalgam rarely demonstrates microleakage. It effectively protects the dentin from secondary caries and prevents pulpal inflammation due to leakage.

⑤The enamel was conditioned with the Red Activator, and the crown cemented with Super-Bond. Excess resin should be removed before it cures. It was difficult to clean up the excess resin in the proximal areas. As much as possible was removed before the resin had completely cured. (May. 1988)

⑥Nine years after cementation, the crown continues to functioned well. (Aug. 1997)

⑦A radiograph nine years after cementation. (May. 1997)

9-5: Dentin sealing for cervical caries

①The patient complained of sensitivity to cold water. Cervical caries was found on the buccal surface of the right lower first premolar. Before restoration, pulp vitality was confirmed using an electric pulp tester.

②Under local anesthesia, the subgingival portion of the lesion was electrosurgically exposed. The carious dentin was removed using a Caries Diagnostic Meter and a caries stain as aids to avoid pulp exposure.

③After confirming there was no pulpal exposure, the Green Activator was applied to the cavity surface for five to ten seconds. Then the surface was rinsed and dried. Super-Bond with the Radiopaque Polymer powder was applied employing the brush-dip technique. This layer of resin adhesive would seal the dentin and protect the pulp.
If it were impossible to remove all the carious dentin, antibiotic agents should be applied and temporized.

④The cavity was filled with resin composite. Two years later, the pulp was vital and there were no clinical symptoms.

9-6: Bonding porcelain laminate veneers

①The patient requested that something be done to improve the esthetics of severely discolored upper anteriors.

②Teeth were prepared canine-to-canine for porcelain laminates.

③The prepared surfaces were conditioned and a thin layer of Super-Bond was applied to provide protection and improve adhesion. Ivory and Opaque Ivory Polymer powder were mixed to adjust the shade. In order to keep the adhesive layer thin, more monomer than usual was included in the activated liquid. Super-Bond was applied using the brush-dip technique.

④The bonding surfaces of the porcelain veneers were treated with Porcelain Liner M, and cemented using a low-viscosity shaded resin composite that produced a natural tooth shade.

⑤Anterior view immediately after cementation. The porcelain laminate veneer is an ideal restoration for correcting tooth discoloration when the patient is young. The shallow preparation preserves tooth structure and minimizes potential damage.

⑥After eight years

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